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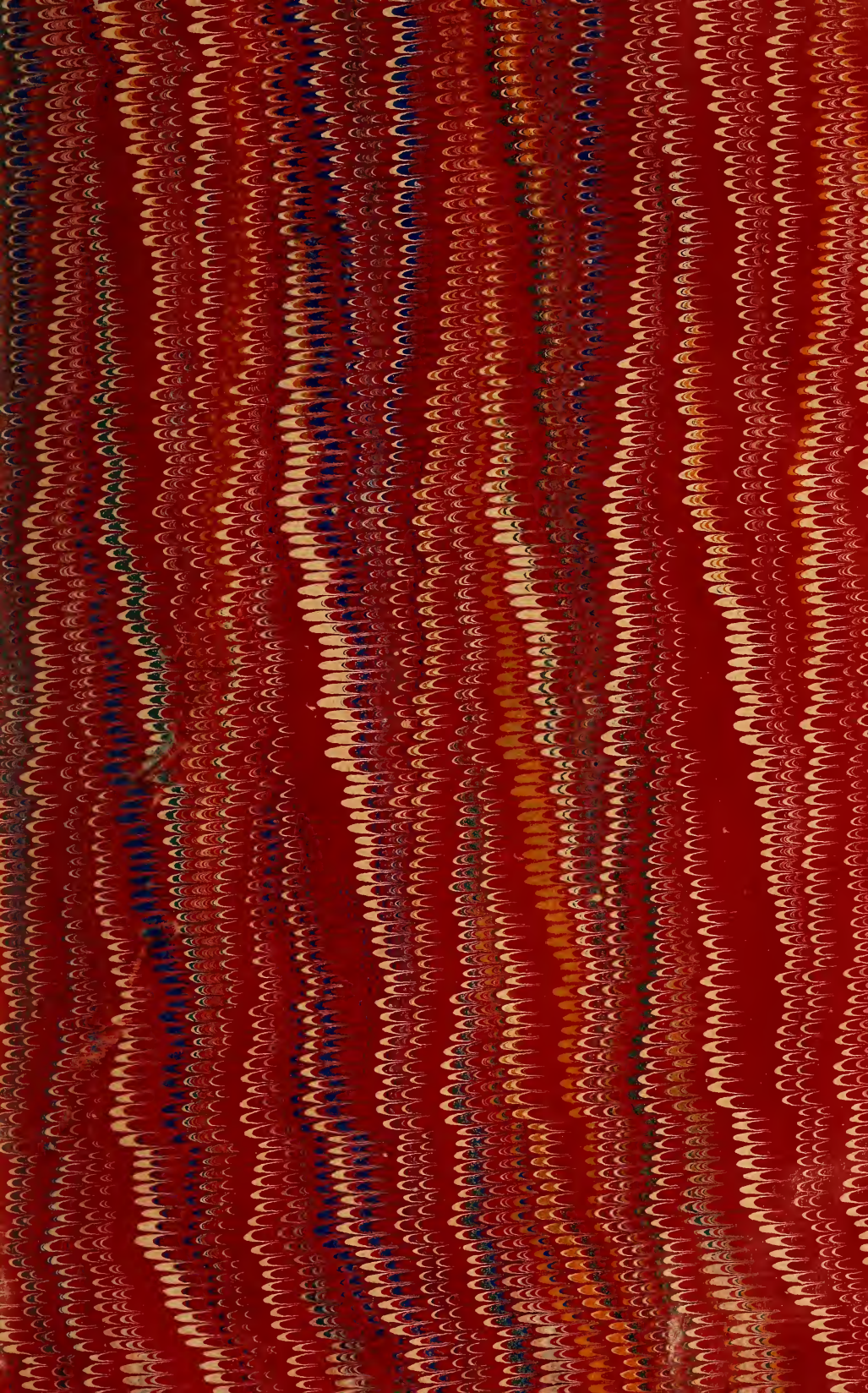
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CEREBRO-SPINAL MENINGITIS.

Report to the State Board of Health upon an Epidemic in Monroe and Lenawee Counties, Michigan; and a Study of some other facts relative to the Cause of the Disease.

BY HENRY B. BAKER, M. D.,

SECRETARY OF THE BOARD, AND MEMBER OF COMMITTEE ON EPIDEMIC, ENDEMIC,
AND CONTAGIOUS DISEASES.

Reprinted from the Second Annual Report of the State Board of Health of the
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CEREBRO-SPINAL MENINGITIS.

REPORT.

To the President and Members of the State Board of Health of Michigan :

GENTLEMEN—Omitting details of circumstances which lead to this report, with which you are already familiar, by the general direction of the board I reached Blissfield in Lenawee county on the 22d of June, having selected that place as a starting point in order to avail myself of the assistance of Dr. H. C. Wyman, who had kindly volunteered to assist in obtaining a history of the epidemic. Dr. Wyman proved himself an energetic and enthusiastic worker in the cause of public health. I wish to acknowledge my indebtedness to him for valuable assistance.

In presenting the facts ascertained with reference to this epidemic, many of them are stated simply as facts supposed to have some bearing upon this subject, while as regards others I have thought that I could not do better than to briefly go over that part of the subject to which it seems to me each particular item presented is more or less closely related, and thus to indicate my own view of at least one of the relations which the item of evidence collected bears to the subject, and the conclusion to which the combined evidence tends. I have also collected, from the literature of the medical profession, numerous isolated facts relative to anatomy, physiology, pathology, and therapeutics, and have endeavored to group them in a way to render them of more practical value to humanity in connection with the study of this disease.

More or less evidence has been collected concerning 88 cases of unusual sickness: 33 cases having occurred at or near the village of Dundee, 40 cases at or near the village of Petersburg, 2 cases at or near the village of Deerfield, 5 cases at or near the village of Blissfield, 2 cases in the township of Raisinville, and 6 cases in or near the city of Monroe.

Monroe, Raisinville, Dundee, and Petersburg are all in Monroe county; Deerfield and Blissfield are in Lenawee county. All these places have indirect, Monroe, Petersburg, and Deerfield have direct railway communication each with the other. The city of Monroe and the four villages named above are all situated on the banks of the River Raisin, which also runs through the township of Raisinville. The river is not a large one; it is not a navigable stream. The water in the river is not clear; in fact, at that time it was quite turbid. There is a mill-dam at each village, and a slight odor sometimes arises from the water, especially as it pours over the dam. At Petersburg complaint was made that a "flood-wood" very near the village was the cause of a bad odor

in its immediate vicinity; and at this and other places I was more than once referred to the river and the dams as the cause of the epidemic from which they had just suffered.

Analysis of water taken from the River Raisin at Deerfield, Sept. 8, 1874, by Prof. R. C. Kedzie of this board resulted as follows: In each imperial gallon, 20.3 grains of solid matter, of which 9.8 grains was organic matter containing nitrogen.

All along the river in this vicinity there are many bayous and flat places which are under water when the water is high, and dry when it is low. Opposite such places one frequently experiences the peculiar pungent odor sometimes given off by aquariums and ferneries containing ferns, mosses, etc., and occasionally this is united with an odor like that from a drained mill-pond in process of drying up.

The prevailing diseases of this locality are usually the intermittent and remittent fevers.

EFFORT TO TRACE THE SPREAD OF THE DISEASE.

I was told that cerebro-spinal meningitis had not prevailed just in this locality for several years, at least not to any great extent. I find, however, on examining the returns of deaths, made by the supervisors, that in 1868 there were in the township of London, which adjoins Dundee, four deaths attributed to "spotted fever." Three of these deaths occurred in one family. In 1871 there was one death, and in 1873 one death in the same township. These were all the deaths returned from Monroe county from this disease in 1867, 1868, 1869, 1870, or 1871. For the year 1872, however, ten deaths were returned, but none of them occurred in either Dundee or Petersburg. For the year 1873, eight deaths from this disease were returned from Monroe county, one having occurred in Dundee and one in Summerfield, in which township the village of Petersburg is situated. Dr. Paquette told me of another death near Petersburg in the fall of 1873, which at the time was thought to be a case of poisoning. He now thinks it was this disease. The patient was a lady, and the body was buried in the village cemetery. Dr. Jackson gave me notes of one case at Dundee, January 1, 1874, which died on the third day.

This epidemic began about the same time at Dundee that it did at Petersburg. The first case at Petersburg occurred March 3, 1874, and the patient was still sick when I was there, June 23. The first case, during the epidemic, at Dundee, occurred March 7,—four days later than the one at Petersburg. The patient was convalescent on the 54th day after the attack. The last case at Dundee was attacked May 4. Most of the cases at Dundee occurred during March and April, while most of the cases at Petersburg were in April and May. Those at Deerfield were in May. The cases of unusual sickness at Blissfield occurred in May and June.

IS THE DISEASE COMMUNICABLE?

From the preceding statement of cases of the disease in that vicinity previous to this epidemic, it will be seen that there appears to have been abundant opportunity for the disease to have spread either by contagion or infection, if it is ever possible for it to spread in such manner.

The physicians in the villages visited were unanimous in saying that they saw no conclusive evidence of its being contagious. I collected some evidence

which might be construed in a way to show that it was communicable in some manner, but which was nearly as well explained by the fact of persons having been placed under similar conditions. In relation to this subject, John Netten Radcliffe, in his essay on "Epidemic Cerebro-Spinal Meningitis," in J. Russel Reynolds' "System of Medicine," says:

"The great majority of observers have come to the conclusion that the disease is incommunicable from the sick to the well. Among the minority who hesitate to accept this deduction without reservation are Professor Hirsch, Professor Stokes, and Mr. J. Simon. The facts which suggest the possibility of the active cause of the disease being portable in some way are of the following character: (a) A child was seized with epidemic cerebro-spinal meningitis and died. A second child of the same family was attacked with the malady a few days later. The day following the attack of this child, the mother, who slept in the same bed with it, sickened of the disease.¹

"(b) 1. On the 8th of February, 1865, a youth, aged 20 years, was attacked with the characteristic symptoms of epidemic cerebro-spinal meningitis. He was nursed by a woman from another village. The youth died, and after his death the woman returned home. She soon sickened, and she died of the epidemic disease on the 26th February. There had been but one case previously in the village. To the interment of the woman, the funeral obsequies, as customary in the district, being performed with the coffin open, came a family from another locality. After the return home of this family, a child three months old, sickened immediately of meningitis, and died within twenty-four hours. Then a man who had accompanied the family to the interment was attacked with the disease, and died on the 2d of March. Lastly, a girl in the same locality who had also been at the funeral, was seized, and died on the 7th March. 2. At another village, two children of one family, aged three and a half and one and a half years respectively, died of the epidemic,—one on the 27th January, the other on the 7th February. The clothes of the deceased were taken to a neighboring village, and came into the possession of a girl aged five years. She soon sickened of the epidemic, and died on the 14th February."²

"It is obvious that contagiousness of a like character to that of small-pox, scarlet fever, or typhus, is not possessed by the malady under consideration. The question is: Does epidemic meningitis, like typhoid fever or cholera, possess a peculiar contagiousness of its own, a property of communicability peculiar to itself? This has yet to be solved."

PREVIOUS CASES NOT FAR DISTANT.

In addition to the cases already mentioned, I was told that cases of the disease occurred the preceding fall in Milan, eleven miles from Dundee. There is direct railway communication between Milan and Dundee. Three or four rivers run through the township and afterwards empty into the river Raisin, but below Dundee and all the other places named, except Raisinville and Monroe. Cases were also reported as having occurred at Manchester, in Washenaw county. Since then I have visited Manchester, and found that the disease prevailed there in the preceding August, 1873. There is direct railway communication between Manchester and Blissfield, and communication with the other places by changing cars. Manchester is situated on the river Raisin,

¹ Professor Stokes, *The Medical Press and Circular*, June 19, 1867, p. 532.

² Hirsch, *Transactions of the Epidemiological Society*, vol. 2, p. 373.

nearer its source than any of the places yet named. Cases have been reported as having occurred previous to that time in Jackson county, at different places along this same river Raisin still nearer its source, and in the city of Jackson, which has direct railway communication with Manchester and Blissfield. In the returns of deaths for the year 1873, the supervisor of the township of Norvell reports one death from this disease on the 13th of April, 1873. The village of Norvell is on the bank of the river Raisin, above Manchester. Deaths are also reported from this disease in Napoleon, in the spring of 1873.

As it is possible that undue importance may be attached to the fact that cases of this disease occurred along this river, and were traced backwards in order of time as the stream was ascended toward its source, it may be well to state that during the spring of 1873, this disease prevailed in various localities throughout the State. The returns of deaths for that year have not yet been compiled in a way to show how extensively, but an examination of the returns for Branch county reveals the fact that 32 deaths are returned from "cerebrospinal meningitis," "spinal fever," etc. According to the proportion of deaths to cases in Petersburg, Dundee, and Blissfield, those 32 deaths represent about one hundred cases of the disease in Branch county during the year 1873. The returns for Ingham county include 15 deaths, which may, probably, be attributed to this disease, some of them appearing, however, as deaths from "spinal fever." For Allegan county the returns show 98 deaths during the year 1873, from specified causes such as may be supposed to be this disease, modified by different circumstances, such as age, sex, inter-current disease, etc. Following back, it appears from the returns of deaths from Allegan county, for the year 1872, that there were in that year 12 deaths from this disease. In 1871 there were 5 deaths. For 1870, and for 1869, no deaths were returned from that county from that cause; but one death is returned as having occurred in October, 1868.

At different times in the past, this disease has prevailed more or less extensively at several places within this State. But any attempt to trace it now is attended with very great difficulty, for the reason that the attention of physicians, and of the people, was at that time almost entirely directed to efforts in the direction of cure, and no permanent provision had then been made, either for studying the cause of the disease, or recording the coincident facts and results that it might afterward be studied.

Mortality statistics have only been collected in Michigan since 1867. The first statistical evidence of this disease in Michigan, was in the second Registration Report, for the nine months ending December 31, 1868, in which are reported 7 deaths from "spotted fever." For the year 1869, there were reported 5 deaths; for 1870, 9; and for 1871, 18 deaths. During the year 1872, the number of deaths from this disease appears to have been much increased, and in 1873 very greatly increased, as indicated by the returns from the three counties before referred to,—Branch 32, Ingham 15, and Allegan 98 deaths. The deaths during the year 1874, will not be enumerated until the spring of 1875, but it seems probable that in 1874, there were in the State a less number of deaths from the disease under consideration than occurred during the year 1873. In Lansing, several deaths from this disease occurred in the spring of 1873, while the disease did not prevail there in 1874. In view of these facts, we have, among other questions, to consider why the disease prevailed so extensively at Petersburg and Dundee in 1874, and did not in 1873, when some other localities within the State were suffering most severely.

PREVALENCE OF THE DISEASE OUTSIDE OF THIS STATE.

In a report to the New York City Board of Health, Dr. Moreau Morris, City Sanitary Inspector, says: "During the early part of January, 1872, reports of a 'new form of disease' began to reach the Bureau of Sanitary Inspection. Some called it 'spotted fever,' others 'epidemic meningitis,' a 'fever resembling typhoid,' and 'typhoid complicated with acute meningitis.'" "Isolated cases had occurred during previous years." "Deaths had been recorded from 'cerebro-spinal meningitis,' in 1866, 18; in 1867, 32; in 1868, 34; in 1869, 42; in 1870, 32; in 1871, 48." From January 1 to November 1, 1872, 761 deaths from this disease were reported to the Health Department of New York city.

From a report to the State Board of Health of Massachusetts, in 1873, by J. Baxter Upham, M. D., it appears that the first reliable record of this disease as an epidemic in that State was of 9 fatal cases in the town of Medfield in March, 1806. "It prevailed quite extensively in 1810." Between the years 1806 and 1816 it appeared at intervals at various points within the State. From that time little was heard of the disease until March, 1849. "It appeared again, to a limited extent, in April, 1857." Below is a statement of cases reported in 1866 to the Medical Society of that State:

In 1857 there were	3 cases.
" 1858 " "	27 "
" 1859 " "	3 "
" 1860 " "	" "
" 1861 " "	5 "
" 1862 " "	5 "
" 1863 " "	7 "
" 1864 " "	88 "
" 1865 " "	116 "
" years not designated there were	26 "
Total	280 "

In 1866 the record was not complete, but included 7 cases. From that time until 1872 no proper record could be found, as regards the State, but in the city of Boston there were returned, in 1867, 7 deaths; in 1868, 8 deaths; in 1869, 7 deaths; in 1870, 5 deaths, and in 1871, 3 deaths. In 1872 it appears for the first time in the State nosological records under its true name." In that year 175 deaths were returned from this cause, the cases being scattered throughout the State. In the epidemic of 1873 there were reported 517 cases of the disease, and the mortality is stated to have been "a little less than 44 per cent"—(about 227 deaths?) At this rate of mortality the 175 deaths in 1872 would represent about 397 cases of the disease.

This disease has prevailed in different parts of the civilized world since 1805, and it may be for a long period of time previous to this century. I shall make no elaborate attempt to give a history of the disease. It is not at all probable that it would be possible for any person to give a complete history, for the reason that it not infrequently happens that it is called by some other name. "It was not recognized as a distinct affection until the beginning of the present century."* "While Paumier describes something very much like it

*Stille.

at Paris in 1568, the first clearly recognized occurrence of it was at Geneva in 1805; after which it was traced in a number of different localities on the Continent in 1806-7, 1811, 1813-14-15-16, and 1823. At Geneva, "the characters described were: Sudden attack in the night, vomiting of green matter, atrocious cephalalgia, spinal rigidity, difficulty of deglutition, convulsions, nocturnal exacerbations, petechiæ, death occurring after from twelve hours to five days of illness. At Grenoble, in 1814, one variety was observed with tetanus, and another without tetanus. In the department of Landes, 1837, there was also remarked, in certain cases, exaltation of the tegumentary sensibility. The disease attacked persons of all ages, and both sexes, although the smallest number of cases occurred in females." *

In another part of this report, in connection with the subject of "Food as a cause of this disease," reference is made to various other epidemics of cerebro-spinal meningitis, most of which occurred in foreign countries. Also, in connection with "An effort to trace the cause of some previous epidemics," reference is made to some others which have occurred in this country.

TABLE I.—Exhibiting for each Case of Cerebro-Spinal Meningitis reported as having occurred in Lenawee and Monroe counties during the epidemic of 1874, the Residence, Date of Attack, Sex, Age, Day of Death after Attack, and Day of Convalescence after Attack.

RESIDENCE OF PATIENT AT OR NEAR	DATE OF ATTACK.	SEX.	AGE IN YEARS.	Day of Death after Attack.	Day of Convalescence after Attack.
Dundee.....	January 1st..	Male.....	6	3d	----
Petersburg.....	March 3d....	Male.....	13	149th	----
Dundee.....	March 7th....	Female....	10-12	----	54th
Dundee.....	March 8th....	Male.....	21	----	17th
Dundee.....	March 13th...	Male.....	9	68th	----
Petersburg.....	March 16th...	Male.....	7	3-24	----
Ida.....	March 18th...	Male.....	14	----	21st
Dundee.....	March 20th...	Male.....	15	----	10th
Dundee.....	March 20th...	Female....	19	2d	----
Dundee.....	March 22d....	Male.....	5	----	28th
Dundee.....	March 22d....	Male.....	44	7th	----
Dundee.....	March 23d....	Male.....	32	----	8th
Dundee.....	March 24th...	Male.....	23	7th	----
Dundee.....	March 25th...	Male.....	2	----	24th
Petersburg.....	March 25th...	Male.....	17	10th	----
Dundee.....	March 26th...	Male.....	5	4th	----
Dundee.....	March 26th...	Male.....	4	----	19th
Dundee.....	March 29th...	Male.....	18	3d	----
Monroe.....	March 29th...	Female....	17	----	24th
Dundee.....	March 30th...	Male.....	3	----	31st
Dundee.....	March 31st...	Female....	11	----	31st
Dundee.....	April 1st....	Male.....	3	----	28th
Dundee.....	April 1st....	Female....	2½	----	14th
Dundee.....	April 2d....	Male.....	½	6th	----
Dundee.....	April 2d....	Female....	23	22d	----
Dundee.....	April 3d....	Male.....	5	----	9th
Dundee.....	April 4th....	Male.....	27	----	3d
Dundee.....	April 4th....	Male.....	6	----	26th
Monroe.....	April 4th....	Male.....	23	----	16th
Dundee.....	April 6th....	Female....	26	----	39th
Dundee.....	April 7th....	Male.....	3	----	32d
Petersburg.....	April 7th....	Male.....	1½	----	56th

* Dr. Henry Hartshorne, quoted from the Am. Jour. of Med. Sci., July, 1864, p. 93.

TABLE I.—Continued.

RESIDENCE OF PATIENT, AT OR NEAR	DATE OF ATTACK.	SEX.	AGE IN YEARS.	Day of Death after Attack.	Day of Convalescence after Attack.
Raisinville.....	April 7th.....	Female.....	12	----	68th
Dundee.....	April 8th.....	Male.....	30	----	54th
Raisinville.....	April 9th.....	Female.....	12	----	15th
Petersburg.....	April 10th.....	Female.....	13	86th	----
Dundee.....	April 11th.....	Male.....	23	----	9th
Petersburg.....	April 16th.....	Male.....	9	----	20th
Petersburg.....	April 16th.....	Male.....	13	----	79th
Dundee.....	April 18th.....	Female.....	20	----	9th
Dundee.....	April 19th.....	Male.....	29	26th	----
Dundee.....	April 20th.....	Male.....	4	----	18th
Monroe.....	April 20th.....	Male.....	17	----	71st
Petersburg.....	April 23d.....	Male.....	43	6th	----
Petersburg.....	April 28th.....	Female.....	13	----	35th
Peter-burg.....	April 29th.....	Male.....	46	6th	----
Petersburg.....	April 29th.....	Female.....	21	----	4th
Dundee.....	April 30th.....	Female.....	28	----	25th
Petersburg.....	May 2d.....	Male.....	1 ¹ / ₂	----	4th
Petersburg.....	May 2d.....	Male.....	44	----	35th
Petersburg.....	May 2d.....	Male.....	40	4th	----
Dundee.....	May 3d.....	Male.....	29	----	17th
Dundee.....	May 4th.....	Female.....	24	----	25th
Monroe.....	May 4th.....	Female.....	5	27th	----
Petersburg.....	May 5th.....	Female.....	14	----	30th
Petersburg.....	May 5th.....	Female.....	11	5th	----
Peter-burg.....	May 5th.....	Female.....	4	----	*
Blissfield.....	May 6th.....	Male.....	21	----	3d
Petersburg.....	May 8th.....	Female.....	8	2d	----
Blissfield.....	May 10th.....	Male.....	10	----	3d
Petersburg.....	May 10th.....	Female.....	23	----	37th
Petersburg.....	May 10th.....	Female.....	12	2d	----
Petersburg.....	May 12th.....	Male.....	14	----	17th
Petersburg.....	May 12th.....	Female.....	75	----	5th
Petersburg.....	May 12th.....	Female.....	11	----	14th
Petersburg.....	May 12th.....	Female.....	3	----	14th
Petersburg.....	May 12th.....	Female.....	2	----	14th
Petersburg.....	May 12th.....	Female.....	12	7th	----
Deerfield.....	May 13th.....	Male.....	20	----	10th
Deerfield.....	May 14th.....	Female.....	7	3-24	----
Petersburg.....	May 18th.....	Female.....	30	----	8th
Monroe.....	May 18th.....	Female.....	7	17th	----
Petersburg.....	May 19th.....	Female.....	36	4th	----
Petersburg.....	May 19th.....	Female.....	6	----	*
Petersburg.....	May 19th.....	Female.....	50	4th	----
Petersburg.....	May 22d.....	Female.....	15	4th	----
Petersburg.....	May 22d.....	Female.....	12	----	29th
Monroe.....	May 27th.....	Male.....	5	----	10th
Petersburg.....	May 29th.....	Male.....	45	----	11th
Blissfield.....	May 30th.....	Female.....	35	----	10th
Petersburg.....	May 31st.....	Male.....	63	5th	----
Petersburg.....	May 31st.....	Female.....	60	3d	----
Petersburg.....	June 2d.....	Female.....	18	----	2d
Petersburg.....	June 4th.....	Male.....	5	----	8th
Petersburg.....	June 9th.....	Female.....	45	----	7th
Blissfield.....	June 18th.....	Female.....	30	----	2d
Blissfield.....	June 23d.....	Female.....	37	----	3d
Petersburg.....	June 23d.....	Female.....	47	----	?
Petersburg.....	Male.....	6	?	----

* Sick June 24, 1874.

TABLE II.—*Exhibiting by Sex and by Age, the number of Cases of Cerebro-Spinal Meningitis in Petersburg, Dundee, Deerfield, Blissfield, Raisinville, Ida, and Monroe, during the Epidemic in Spring of 1874.*

LOCALITY.	SEX.	AGES IN YEARS AND PERIODS OF YEARS.													
		All Ages.	Under One Year.	1 to 2.	2 to 5.	5 to 10.	10 to 15.	15 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 & ov'r
Total of all localities visited ..	Total....	89	2	2	9	17	15	9	16	7	8	1	2	1	---
	Males....	47	1	2	5	12	4	5	9	2	6	---	1	---	---
	Females..	42	1	---	4	5	11	4	7	5	2	1	1	1	---
Petersburg {	Total....	40	---	2	3	6	11	3	2	2	7	1	2	1	---
	Males....	16	---	2	---	4	3	1	---	---	5	---	1	---	---
	Females..	24	---	---	3	2	8	2	2	2	2	1	1	1	---
Dundee --- {	Total....	33	2	---	6	7	1	3	11	2	1	---	---	---	---
	Males....	24	1	---	5	7	---	2	6	2	1	---	---	---	---
	Females..	9	1	---	1	---	1	1	5	---	---	---	---	---	---
Deerfield --- {	Total....	2	---	---	---	1	---	---	1	---	---	---	---	---	---
	Males....	1	---	---	---	---	---	---	1	---	---	---	---	---	---
	Females..	1	---	---	---	1	---	---	---	---	---	---	---	---	---
Blissfield --- {	Total....	5	---	---	---	---	1	---	1	3	---	---	---	---	---
	Males....	2	---	---	---	---	1	---	1	---	---	---	---	---	---
	Females..	3	---	---	---	---	---	---	---	3	---	---	---	---	---
Raisinville {	Total....	2	---	---	---	---	2	---	---	---	---	---	---	---	---
	Males....	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Females..	2	---	---	---	---	2	---	---	---	---	---	---	---	---
Ida ----- {	Total....	1	---	---	---	---	---	1	---	---	---	---	---	---	---
	Males....	1	---	---	---	---	---	1	---	---	---	---	---	---	---
	Females..	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Monroe --- {	Total....	6	---	---	---	3	---	2	1	---	---	---	---	---	---
	Males....	3	---	---	---	1	---	1	1	---	---	---	---	---	---
	Females..	3	---	---	---	2	---	1	---	---	---	---	---	---	---

TABLE III.—*Exhibiting, by Sex and by Age, the number of Deaths from Cerebro-Spinal Meningitis in Petersburg, Dundee, Deerfield, Blissfield, Raisinville, Ida, and Monroe, during the Epidemic of 1874.*

THIS EPIDEMIC.	SEX.	AGES IN YEARS AND PERIODS OF YEARS.													
		All Ages.	Under One Year.	1 to 2.	2 to 5.	5 to 10.	10 to 15.	15 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 & ov'r
Deaths.... {	Total....	29	1	---	---	8	5	4	3	1	4	1	2	---	---
	Males....	15	1	---	---	4	1	2	2	---	4	---	1	---	---
	Females..	14	---	---	---	4	4	2	1	1	---	1	1	---	---

Of the 29 persons who died of this disease in this epidemic :

13 out of 29 died on or before the 4th day of the disease.

15 " " " " " " " " 5th " " " "

18 " " " " " " " " 6th " " " "

21 " " " " " " " " 7th " " " "

The eight others died as follows: 1 on the 10th; 1 on the 17th; 1 on the 22d; 1 on the 26th; 1 on the 27th; 1 on the 68th; 1 on the 86th; 1 on the 149th. This last was the first well-recognized case at Petersburg.

The mortality was greatest in the first part of the epidemic. If the 88 cases in which the date of attack was specified be divided in three parts according to date of attack, out of the first 29 cases there were 12 deaths, out of the next 30 cases there were 8 deaths, and in the last 29 cases there were 9 deaths.

The death-rate in this epidemic was smaller than usually reported, being only 32.95 per cent of all cases. In the epidemic in Massachusetts during the year 1872 it is reported by Dr. Upham as "a little less than 44 per cent."*

In New York city in 1872, it was reported as 75.45 per cent. It is possible that the large death-rate in New York may be accounted for in part by a failure to report cases in as great proportion as deaths, and in part by unsanitary conditions. It is also possible that the death-rate is quite frequently stated too high because of the constant effort of those who study the disease to exclude all except undoubted cases, which usually means severe cases. Mild cases should, if possible, be considered as well, for they may be important in tracing the cause.

During the first part of this epidemic more males than females seem to have been attacked with the disease. The sexes were attacked as follows:

Petersburg-----	{	First half 11 males, 7 females.
	{	Last half 4 males, 18 females.
	{	Unknown date 1 male, 1 female.
Dundee-----	{	First half 13 males, 3 females.
	{	Last half 11 males, 5 females, 1 unknown sex.
Blissfield-----	{	First half 2 males, 0 females.
	{	Last half 0 males, 3 females.
Deerfield-----	{	One case—1 male.
All cases in this epidemic-----	{	First half 33 males, 11 females.
	{	Last half 13 males, 31 females.
	{	Unknown date 1 male, 0 females.
Elmira, N. Y., 1856-7-----	{	First half 18 males, 4 females
	{	Last half 12 males, 8 females, 1 unknown sex.

On page lxxv. of the Registration Report of Massachusetts for the year 1873 it may be seen that during the first part of the year more males than females died from this disease, and in the latter part of the year the reverse was true.

DEATHS from Cerebro-Spinal Meningitis in Massachusetts in 1873.

Sex.	1873.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Males-----	393	9	14	59	91	79	42	35	25	12	8	8	11
Females-----	354	4	11	48	94	65	37	28	17	13	10	16	11
Totals ----	747	13	25	107	185	144	79	63	42	25	18	24	22

Whether or not this was an expression of any general tendency can hardly be determined from the material at hand, no other data having been published heretofore, so far as I can learn, which will enable me to ascertain the fact.

The average age of all persons of both sexes taken with cerebro-spinal

* Report S. B. of Health of Mass., 1874, p. 803.

meningitis at Dundee, Petersburg, Monroe, Raisinville, Deerfield, Blissfield, and Ida, during this epidemic, and the average age of each of three equal parts of the whole number, divided according to date of attack, was as follows:

Cases. ----	{	Average age of first third.....	13.56 years.
		Average age of second third.....	18.79 years.
		Average age of all cases.....	19.22 years.
		Average age of last third.....	25.31 years.

The average age of all who died of this disease during this epidemic, stated as above, according to date of attack, was as follows:

Deaths ----	{	Average age of first third.....	16.10 years.
		Average age of all deaths.....	22.40 years.
		Average age of second third.....	24.28 years.
		Average age of last third.....	27.00 years.

In an epidemic of this disease which occurred at Elmira, N. Y., in 1857, in which there were 43 deaths, the average age of all who died, stated as above, according to date of attack, was as follows:*

Deaths ----	{	Average age of first third.....	11.21 years.
		Average age of all deaths.....	13.92 years.
		Average age of second third.....	14.26 years.
		Average age of last third.....	16.29 years.

Excepting the deaths during the epidemic at Elmira, reported by Dr. T. H. Squire, I have searched in vain for any table or record of cases from which I could gather information on the subject noted above, as taken from Table I. of this report. So far as this evidence goes, it seems to show that those first attacked are younger than those who are attacked later in the same epidemic.

Dividing the 29 fatal cases in the epidemic in this State into three groups, according to age of decedents, I find 14 aged under 15 years, 7 aged between 15 and 30 years, and 8 aged over 30 years. Now, although those first attacked were the youngest, the average duration of the disease was also greater among those aged under 15 years, as appears as follows:

Average duration of fatal cases--	{	14 aged under 15 years, 26.87 days.
		7 aged 15 to 30 years, 10.57 days.
		8 aged over 30 years, 4.87 days.

The mortality was least among those cases aged 15 to 30, and greatest among those aged 30 years and over. Dividing the 88 cases of which the result is stated into three groups as above, I find 45 cases, including 14 deaths, in the first group; 24 cases, 7 deaths, in the second group; and 19 cases, 8 deaths, in the last group. The death-rate is as follows:

Proportion of deaths to cases.....	{	Among persons aged under 15 years, 31.11 per cent.
		Among persons aged 15 to 30 years, 29.17 per cent.
		Among persons aged 30 years and over, 42.10 per cent.

The question relative to what classes of persons are first attacked by this disease is a very interesting one, and one which does not seem to have been studied heretofore. In order to answer this question, it is essential to have the material grouped in a different manner than it is usually tabulated. Tables of cases arranged by ages alone, as is quite common, or by months alone, as is occasionally done, are of no use for this purpose. It is essential to have the

* Computed from a report of deaths during the epidemic by T. H. Squire, M. D., in Trans. N. Y. State Med. Soc., 1858.

important facts relative to all cases so grouped as that the date of attack, sex and age of patient, duration and result of the disease, shall all appear in connection with each other, as they do in Table I., relative to this epidemic. Inasmuch as evidence of this kind is not very accessible, I have thought it advisable to compile such a table from the report of fatal cases in the epidemic at Elmira, N. Y., published by T. H. Squire, M. D., in Trans. N. Y. State Med. Soc., 1858. From this table the preceding items relative to that epidemic have been taken.

TABLE IV.—*Exhibiting the Date of Attack, Sex, Age, and day of Death after Attack, for each fatal case of Cerebro-Spinal Meningitis reported as having occurred at or near Elmira, N. Y., in epidemic of 1856-7.*

DATE OF ATTACK.	Sex.	Age in Years.	Day of Death after Attack.	DATE OF ATTACK.	Sex.	Age in Years.	Day of Death after Attack.
1856.				1857.			
Dec. 23.....	Male....	14	5	March 25.....	Male....	2	2
1857.				March 26.....	Male....	36	285
January 1.....	Male....	13	5	March 26.....	Male....	16	4
February 11.....	Female..	7	3	March 28.....	Female..	11	120
February 13.....	Male....	8-12	3-24	March 30.....	Male....	8-12	18-24
February 2.....	Female..	5	7-24	April 2.....	Male....	4	3
February 24.....	Male....	12	1	April 5.....	Female..	17	6
March 4.....	Male....	1 1-3	6-24	April 6.....	Female..	41	2
March 6.....	Male....	6	1	April 7.....	Male....	17	64
March 9.....	Male....	10	3	April 8.....	Female..	4	4
March 10.....	Male....	5	1	April 13.....	Male....	19	5
March 10.....	Male....	30	3	April 28.....	Female..	11	2
March 12.....	Male....	42	1	May 5.....	Male....	23	14-24
March 14.....	Male....	4	14-24	May 6.....	Female..	4	12-24
March 16.....	Male....	7	3	May 19.....	3-12	2-24
March 20.....	Male....	7	53	May 19.....	Male....	2	6-24
March 21.....	Male....	8	6-24	May 21.....	Female..	1 1-6	12-24
March 21.....	Female..	6	2-24	May 24.....	Male....	40	5
March 21.....	Male....	25	9	May 27.....	Male....	7	4-24
March 24.....	Male....	39	3	May 27.....	Female..	32	3
March 23.....	Female..	23	1	June 20.....	Male....	23	18
March 25.....	Male....	5	1	August 15.....	Male....	20	4

At Elmira, N. Y., in 1856-7, the average duration of the disease was greater in the last half than in the first half of the fatal cases, as appears as follows:

Average duration of fatal cases } First 22 attacked, 4 days and 11 hours.

at Elmira, N. Y., in 1856-7... } Last 21 attacked, 25 days and 3 hours.

The average duration of fatal cases in this epidemic in Michigan was as follows:

First 14 fatal cases attacked, 28 days and 2 hours.

Last 15 fatal cases attacked, 6 " " 9 "

As stated on a preceding page, however, the mortality was greatest among those first attacked.

DEFINITION OF CEREBRO-SPINAL MENINGITIS.

The following definition is from Dr. Clymer's work on this subject:

"Definition.—[An acute specific disorder, commonly happening as an epidemic, general or limited, and, rarely, sporadically, caused by some unknown external influence; of sudden onset, rapid course, and very fatal; its chief

symptoms referable to the cerebro-spinal axis, are, great prostration of the vital powers, severe pain in the head and along the spinal column, delirium, tetanic and occasionally clonic, spasms, and cutaneous hyperæsthesia, with, in some cases, stupor, coma, and motor paralysis; attended frequently, with cutaneous hæmic spots; its morbid anatomical characters being congestion and inflammation of the membranes of the brain and spinal cord, particularly the pia mater, although there is reason to believe that the evidence of these changes may be wanting, even in cases of long duration.”]

“The name cerebro-spinal meningitis is not a proper one for this affection, even with the prefix ‘epidemic,’ for, as Dr. Valleix remarks, it is ‘begotten of anatomical bias and an incomplete appreciation of the facts.’ It gives no accurate notion of the real nature of the disorder, and takes heed only of the local structural changes, which are, probably, secondary, and may be wanting. It has also been called *typhoid meningitis*, *malignant meningitis*; but to these names the same objections lie. *Spotted fever* is hardly distinctive enough, there being so many other essential disorders in which spots on the skin appear. *Petechial fever* has been proposed by Dr. G. B. Wood, of Philadelphia. Dr. W. Stokes calls it *malignant purpuric fever*; and Dr. R. D. Lyons *febris nigra*.”*

“The name of the disease is apt to fix the attention on local structural changes (which are probably only secondary, and may not always be present) to the exclusion of a consideration of the real nature of the malady.”†

Dr. Rodenstein has proposed the name *Tetanoid Fever*. I will hereafter give reasons why I think it the best name yet proposed, although I do not quite agree with the last paragraph quoted. He says:

“But in a not inconsiderable number of autopsies no such evidence of inflammation could be found in the envelopes of the cerebro-spinal axis. These cases, although not as numerous as the others, are nevertheless sufficient to prove that the disease under consideration is not a meningitis. Can we conceive of a pneumonia which in the event of a fatal issue would show no evidence of inflammation of the lung? Is it easier to conceive of a meningitis without the signs of an inflammation of the meninges?‡

“I believe that meningitis stands in a relationship to tetanoid fever similar to that which nephritis sustains to scarlatina; and that iridio choroiditis, labyrinthitis, arthritis, etc., are independent manifestations of a general tendency of tetanoid fever to local inflammation, of which meningitis is another and the most conspicuous illustration.”§

The following remarks by Dr. Stillé tend toward a similar conclusion:

“As the pulse never acquires the force and sustained frequency which belongs to it in pure inflammations or in idiopathic fevers, so the heat of skin is always less than in those affections, and is constantly undergoing vicissitudes such as are observed in no other disease.”||

In April, 1863, Dr. W. W. Gerhard reported to the College of Physicians of Philadelphia relative to “Spotted Fever” occurring in neighboring towns in the vicinity of that city. In speaking of the nature of the disease he said:

“The anatomical lesions thus confirmed the conclusions at which I had already arrived respecting the pathology of the disease. That is, it is strictly

* Meredith Clymer's *Cerebro-Spinal Meningitis*, pp. 5-6.

† Quoted from Aitken's *Sci. and Prac. of Med.*, Vol. II., p. 443.

‡ “Thermometry in Cerebro-Spinal Meningitis,” by C. F. Rodenstein, M. D., pp. 210, 211.

§ Stillé on *Epidemic Meningitis*, p. 57.

a blood disorder unconnected with any structural lesion. The internal ecchymoses of blood are precisely similar to the spots on the skin, and are evidently depending on the same cause. This fact establishes a wide distinction between them and those appearing in typhus and typhoid fevers, as well as the eruptions of the exanthemata. Although the proof of spotted fever being a blood disease is to my mind conclusive, it must not be ascribed to an impoverished condition of this fluid from innutritious or deficient food, as none of the patients whom I saw was in a condition of actual poverty, and a large majority of them belonged to a class amply supplied with all the comforts of life." *

In April, 1864, Dr. Levick reported some cases of "Spotted Fever" to the College of Physicians of Philadelphia. In the course of his report he referred to the nature of the disease as follows:

"Nor do I doubt that there may be in many cases of spotted fever, especially when it assumes the chronic form, inflammation of the meninges of the brain and spinal cord, but that this is necessarily present,—constitutes the essence of the disease,—I do not believe. In scarlet fever we have almost uniformly inflammation of the throat, but no one looks upon scarlatina as mere angina; in measles we have coryza and catarrh, but rubeola is not simply inflammation of the air-passages. Still more strikingly there are in typhoid fever inflammation and ulceration of Peyer's glands with suppuration of those of the mesentery, but certainly no one regards this fever as simply meso-enteritis. These are concomitants, frequent concomitants, of these diseases, local manifestations of a general constitutional disorder, which may be present or may be absent. So with spotted fever. That this is not simple cerebro-spinal meningitis is proved by the fact that though present in some cases, in others all traces of intracranial inflammation have been absent, and this too when all other phenomena of the disease have been characteristically developed. Nor are the remedies which have been found most useful in spotted fever those which are recognized as suited to inflammation of the brain or its meninges. The testimony which comes to us from almost every quarter, with astonishing unanimity, is that blood-letting, mercury, and other familiar antiphlogistic measures are utterly inefficient, are indeed worse than useless, while the only medicines, the exhibition of which has been attended with any success, are quinia, brandy, and turpentine, the remedies everywhere recognized as those suited to the typhus state. Tried thus by the therapeutic test, the disease fails to hold its position as one of pure inflammation, unless indeed we abandon all our former standards of pathology and of treatment. Hence it is that the name cerebro-spinal meningitis is an objectionable one, as giving erroneous impressions as to the nature of the disease, and as leading to an injudicious and dangerous course of treatment." * *

"If, then, this disease be not simple cerebro-spinal meningitis, what is it? I believe it to be, as I have elsewhere expressed it, a malignant febrile disorder, due to a widespread epidemic influence, which acts with intensity on the blood directly, or indirectly through the nervous system. Thus poisoned, the blood is altered in its nature and in its function. Hence follow deranged innervation, impaired nutrition, passive congestions, escape of blood into various tissues, delirium, coma, prostration, and death, the usual results of septicæmia. So far as I can discover, in every autopsy of this disease on record, the

* *Am. Jour. Med. Sci.*, July, 1863, p. 108.

blood has been found to be fluid, both in the heart and great vessels, or if coagula have been found in the heart they have been small and soft.”*

SYMPTOMS USUALLY PRESENT IN THIS DISEASE.

“A chill, headache, vomiting, prostration, morbid sensitiveness of the skin, jactitation, coldness of the surface, wildness of expression, dilated pupils, irregular breathing, paralyzed deglutition, wry neck, retraction of the head, dullness or abolition of the senses, pulse but little affected, bowels quiescent, petechia, delirium, convulsions, coma; these are impressive symptoms, and many, or all of them, attend each case.”†

SYMPTOMS GENERALLY PRESENT IN THIS EPIDEMIC.

The first case at Petersburg of which I have notes was Frank Gunsolus, aged 13 years, taken sick March 3, 1874. He was a brother of a prominent physician of that place, from whom I received some account of the case. He had a chill with vomiting for thirty hours; then violent fever, opisthotonos, lockjaw, and double vision for four days. There was increased sensitiveness of the skin, large copper-colored spots about the size of a five-cent piece, which were tender to the touch. Before his sickness, was attending school, was active mentally, thin and spare, wore flannel underclothing, slept up stairs. The water used by the family has been analyzed, and will be referred to again further on. This boy was still sick when I visited Petersburg, but died July 30th, 149 days from date of attack. Other cases were reported by Dr. Gunsolus, so far as related to dates, ages, etc., but the symptoms generally present were not detailed. He mentioned one case as being deaf, and in reply to question stated that he had given the patient no quinine. The disease seems to have displaced the ordinary intermittent and other malarial fevers.

Dr. Paquette of Petersburg says that the first case of his, this spring, had rash and sore throat, and was mistaken for scarlet fever, which was not to be wondered at, considering the great infrequency of occurrence of spotted fever. The patient was a boy, aged about seven years. He was taken sick March 16th, and died in three hours. The next cases, just one month later, were Charles Boone and Ed. Pierce. Both were taken the same night and same hour. Both played at school together. On the day previous they played “snap the whip.” “They had been whirling the Pierce boy,” and he was sick in school the previous afternoon. “He had quite a taste for learning.” He went into a high fever. Had delirium, which lasted about six hours, during which time his pulse was regular and full; after that it was only about 80 beats per minute. Many other cases had intermittent pulse. He had pain at the base of the brain behind, and at the prominent bone in the back of the neck. While in active delirium he worked incessantly at his school studies. Pierce took no quinine, but was deaf. All the worst symptoms in this case afterwards disappeared.

The patients’ mouths were dry, “their nerves ‘taut.’” I think this somewhat singular remark by Dr. Paquette, embodies an important fact. I interpret his observation to be that there was general muscular tonicidity, which was increased by any irritation of the skin, because of its increased sensitiveness.

The patients’ bowels were generally costive and hard to act upon. The urine was not passed freely. It was high-colored, some of it coffee-ground color. Nearly every case vomited, not bile, but a substance which looked like

* Am. Jour. Med. Sci., July, 1864, pp. 138, 139.

† T. H. Squire, M. D., Trans. N. Y. State Med. Soc., 1858.

chopped grass and water. Some of it looked like indigo, and settled in the bottom of a vessel. None of the patients were tender over the right illiac region; they were tender all over the spine, and movements caused pain. Some of them have been spotted; no pimples were observed. The spots were bluish, were evanescent, and disappeared on pressure.

The eyes were frequently affected with squint, generally convergent, but sometimes divergent. They were generally glassy, with a peculiar stare; the lids did not freely raise or lower, they did not wink with natural frequency. The pupils were generally dilated. Dr. Paquette speaks of a purulent discharge from the nose in some cases; but it was his custom to cause the patients to sneeze, and the discharge may possibly be explained by that fact. Dr. Paquette, from whom this part of the account was received, has four boys and four girls. Three of his girls had the disease in rather a mild form. All taken at the same time, and all recovered. His children had not taken off their underclothing. Another girl that died of the disease had taken off her underclothing the day before she was taken sick. An old lady that died had taken off her underclothing two days before she was taken sick. Two of Dr. Paquette's children slept down stairs and one up stairs. Other cases were about equally divided in this respect, so far as I could learn.

Concerning the case which occurred at Deerfield, I have notes made from a conversation with Dr. S. L. Jones of that place. The patient was a male aged about 20 years; had been at school at Adrian; had been complaining for a few days; was taken sick while dancing about 1 A. M., May 13, 1874; he vomited, had a chill and spasms; his head was thrown back; he was delirious; pupils of his eyes were dilated, but contracted under influence of opium; his bowels were torpid; he had tenderness of the spine and muscles; was convalescent in ten days. In Summerfield a little girl aged 7 years "had symptoms similar to ague, headache, and pains all over her, had fits in the afternoon, and died after three hours."

At Dundee, the symptoms, as described by Dr. G. W. Jackson, were as follows: The patients generally complained for about twenty-four hours of being tired and lame, they had pain in the back of the head, in some cases in front part of head. Some complained of pain down the spine, and some of pain in the ears. In some cases there was a cold stage, and in others a distinct chill. Vomiting was a prominent fact during and after the cold stage. A few were taken as suddenly as if knocked down. There was tenderness of the body, superficial, and also over sciatic and other deep nerves given off from spinal cord. The head was thrown back in some cases, and in others it was drawn to one side. There were spots on the skin, generally over the chest. The spots were variable, were the size of the point to that of the head of a pin; were not elevated above the surface, and did not disappear on pressure. The face was flushed and dark. The eyes were affected with squint in some cases, divergent in a few cases. There was sometimes alternate dilation and contraction of the pupils. The dilation was not constant. The temperature was sometimes elevated at first, sometimes below normal. About the highest temperature noticed was 105°. Respiration was irregular. The pulse was frequently almost normal, sometimes slower than natural, but accelerated after a few days. It was frequently intermittent. Before death there was blueness of surface, and small wiry pulse. The tongue was generally covered with a white pasty coating, through which the papilla were sometimes visible. There was

a tendency to a relapse, beginning with a chill which was sometimes repeated. The patients did not sweat of themselves.

Cases of unusual sickness seen by Dr. M. Wilcox of Dundee, presented symptoms as follows: One case, taken sick March 24, died March 31, male aged about 23, taken with congestive chill which lasted about two hours; fever lasted three days; did not vomit; had no spots; face was flushed; pupils not changed; bowels moved readily; urine high-colored and scanty; no tenderness apparent; there was active delirium. Another case, girl aged 11 years, had sore throat, black-coated tongue, had chills at first, and the case terminated in intermittent fever. This patient was tender over spine and back of neck; had pain in back of head; the muscles of back and neck contracted so that the head and feet were only about twenty inches apart. She had diarrhoea part of the time. This case was convalescent in 31 days. Some other cases seen by Dr. Wilcox had spots on the chest about five-eighths of an inch in diameter.

For the characters of the disease as it occurred in the city of Monroe and vicinity I am indebted to Dr. C. T. Southworth, who kindly wrote me concerning it. I quote from his letters as follows: "The cases were not confined to any one neighborhood or street of the city, but were well scattered in the three wards south of the river. The prodromic stage is of variable duration and quality. Some have intermittent fever for a few days, others suffer from tonsillitis, others laryngitis; still others have none at all, the first symptom being a convulsion. The characteristic symptoms do not vary, but the general symptoms may." He speaks of pain in the head, retraction of the head, lock-jaw, and squint as attending nearly all cases, and "paralysis of the lower extremities in four cases." Dr. Southworth mentions "a falling in of the abdominal walls, the abdomen appearing as though it had been dug out or emptied of the viscera. This last symptom I think I have found in every case I ever saw." I noticed this appearance, which was very striking, in a case which I saw at Petersburg. I do not remember to have seen any reference to this subject until Dr. Southworth's letter. In the article on Tetanus in Youatt's "Structure and Diseases of the Horse," page 80, mention is made of "tucking up of the belly, which is seen under no other complaint." This same expression,—“tucking up of the belly,”—is found in descriptions of the Texas cattle disease. In a report of the Sanitary Committee to the Board of Health of New York city, in June, 1874, relative to hydrophobia, then prevailing in that city, this same condition is referred to as one of the characteristics of dogs suffering from that disease. The expression in that case is: "Skin tight on the ribs, abdomen tucked up." There is a certain similarity between the prominent symptoms of these diseases of animals and cerebro-spinal meningitis; and *post mortem* examination reveals anatomical changes which in some respects are similar. May not this retraction of the abdomen be an important expression of a general and characteristic fact in the pathology of these tetanoid diseases; that fact being general contraction of muscular tissue, more particularly of the non-striated muscles, involving not only muscular coats of arteries but also of intestines, and possibly including the diaphragm.

Dr. Southworth writes that "the disease did not appear there in 1873, but in 1872 I treated 19 cases in Monroe county, with only one fatal case." In reply to a question as to whether the cereals were affected with smut in that locality, he writes: "Smut prevailed in 1873, none in 1874. I cannot learn regarding 1871." The flour being used at the time of the epidemic in 1874 was probably made from wheat raised in 1873.

The cases of unusual sickness at Blissfield were not all well-marked cases of cerebro-spinal meningitis, but have been included for the reason that they were unusual, and seemed to partake of the character of that disease. I am indebted to H. C. Wyman, M. D., for an interesting account of them, including treatment, and give the main parts concerning one or two of them. A boy, aged 10 years, had not felt well for several days, at night was taken with severe pain in the back of his head, was delirious, had tendency to contraction of the muscles of the neck; there was coldness of the extremities. Mustard was applied to extremities and along the spine. He was said to be better next morning when Dr. W. saw him, but was then unable to bend his head forward, and complained of tenderness throughout the body. His pulse was natural, skin dry, bowels constipated, urine thick and scanty. He had no appetite, was convalescent on the third day. A male, aged 21 years, was never sick a day in his life before, after working in the field all day was taken suddenly with pain in the head and vertigo, vomited, and fell to the ground unconscious. Dr. W. found him in bed suffering severe pain in the right sciatic nerve, was very restless, and sick at his stomach. He had tenderness along the spine; pupils irregular; pulse first trial 88, next trial 100 per minute; temperature 102°. Patient had another paroxysm similar to first, but milder, and was unable to work for two weeks, owing to stiffness of muscles.

PATHOLOGY OF THE DISEASE RATIONALLY CONSIDERED.

In a report to the State Medical Society of New York, in 1858, Dr. T. H. Squire remarks as follows: "Neither is it difficult to give a rationale of these manifestations. With the headache, heavy chill, and cold surface, there is violent congestion of the brain; the vomiting and irregular breathing indicates disturbance of the pneumogastric nerve; if there be dilated pupil and loss of sight, they show the nerves of vision to be impaired; when the hearing becomes obtuse, the auricular nerve has suffered; if the sterno-cleido-mastoid and trapezius muscles are rigidly contracted, their congestion or effusion surrounds the spinal accessory; if an arm is convulsed or paralyzed, the difficulty embraces the upper portion of the cord; and in like manner, all the conspicuous symptoms may be explained by the congestion or effusion that exists in the cephalic and vertebral cavities. But having philosophised thus far, it is not so easy to take another step, and account for the congestion, or the inflammation, whichever it may be. The remote cause of this is epidemic, is subtle in its nature, like all other epidemic influences, and makes its impression directly upon the nervous system, without any previous derangement of the blood or the secretions. The exciting causes are exposure to cold and whatever else tends to depress the vital energies of the system. If a neglected child creeps about the cold floor, in wet and scanty clothing, or a delicate boy plays in the snow with damp feet, or a lively school-girl dances and sings till she is exhausted,† or a fisherman wades too long in the river, or a debauchee falls into the canal, they will be quite likely to encounter the disease."*

CAUSE OF CEREBRO-SPINAL MENINGITIS.

Dr. J. Baxter Upham, in the Fifth Annual Report of the State Board of Health of Massachusetts, p. 311, says:

* T. H. Squire, M. D., Trans. N. Y. State Med. Soc. 1858, p. 188.

† The only case of the disease which occurred at Deerfield during this epidemic, was a young man attacked while dancing at an evening party. Over-work and mental anxiety were assigned in a few other cases.

"The relations of insanitary conditions in and around the abode of the patient to its origin or supposed cause, demands the most careful consideration. In weighing the evidence contained in the returns, I find the scale to be pretty evenly balanced in this particular. The cases are distributed among all classes and grades of society,—the high and the low, the rich and the poor, locations unexceptionable for situation, open to abundant light and air, and the pent-up hovels of the lowly and wretched, have all contributed to the material of the epidemic. We believe, therefore, that the *primal* origin of the disease is atmospheric, and for the present beyond our ken."

Dr. John Simon writes:

"Epidemics have seemed particularly apt to occur in establishments where masses of special population have been living in common domicil,—as in work-houses, convict prisons, schools, and (above all) barracks. And in several such cases the epidemic has seemed to confine itself to one section of the establishment, to one block or building, to one floor, or to one room. It is asserted that, as a general rule, the affected segment of population has been in overcrowded and ill-ventilated quarters. And when the disease has spread from such centres, or has independently arisen among common populations, this, almost always, has been said to have been under similar unwholesomeness of circumstances. Where the epidemic has been among soldiers, officers have enjoyed almost entire immunity; and where common populations have been suffering, the disease has shown great, if not exclusive, preference for the worst lodged classes of the community. * * * In some cases, according to local reports, the distribution of an epidemic has very decidedly not been governed by conditions of over-crowding and ill-ventilation.†

This would seem to show that, although over-crowding and imperfect ventilation may increase the tendency to this disease, it cannot be considered as the essential cause; and it may be that the over-crowding, etc., are only accidental conditions, the real cause being some other condition to which "the affected segment of population" is also exposed. The fact of the disease affecting "segments of population" in the way it does, is evidence against the proposition that it has a general atmospheric cause. Officers may have enjoyed immunity from the disease because their food was from a different source and of better quality.

A distinguished writer says:

"But we may regard it as very probable that epidemic cerebro-spinal meningitis does not depend on atmospheric or telluric influences, but is rather due to an infection of the body with a specific poison."*

The fact that the disease sometimes prevails in one locality in one year, and in a subsequent year in another place near by, while the place first visited escapes, would seem to be good evidence that the disease is not due to a general atmospheric cause, for if it were, contiguous places should be attacked simultaneously.

In order that the disease may prevail as an epidemic in the way this disease does, and still be due to such influences, it is essential that many persons, of different ages, and of both sexes, shall be more than usually susceptible to such influences, and that such susceptibility shall be restricted to persons within a certain locality, whereas climatic influences are not usually so restricted. In

† Niemeyer's Text Book of Prac. Med., Vol. II., p. 219.

(* Eighth Report of the Med. Officer of the Privy Council, 1865.) Quoted from Aitken's Sci. and Prac. of Med., Vol. II., p. 453.

short, there seems to be no satisfactory evidence that the disease is due to a general atmospheric cause.

If it is due to any local influence acting through the atmosphere, the nature of that influence remains to be ascertained. The disease has prevailed in localities subject to malarial diseases, but on the other hand it has prevailed in localities not subject to such diseases.

IS IT DUE TO THE LOCAL PRODUCTION OF OZONE?

There is, however, one agent which may be formed and added to the atmosphere in greater quantities in some localities than others, and which from its known action upon organic matter may be supposed to be capable of so acting upon the tissues of the body, and of so influencing the nervous system, as to render it possible for changes in temperature and for mental impressions to produce such phenomena as appear in this disease. That agent is ozone. During normal activity of living bodies in our ordinary atmosphere, the tissues of the body are constantly undergoing change through absorption of oxygen and liberation of the products of oxidation. This expenditure of the substance of the body is nominally compensated by a period of repose and repair during suspension of activities in sleep. But if, instead of ordinary atmospheric oxygen, the inhabitants of a given locality are caused to inhale ozone, which is a much more active form of oxygen, it is in harmony with our present knowledge of its properties, to believe that there may result an over-oxidation of the tissues of the body, and that those destructive changes, which under ordinary circumstances are repaired during sleep, may go on to excessive and even to irreparable destruction. It is quite probable that the results of this over-oxidation, if it occurs, would be first exhibited in a disturbance of the nervous system, through a sense of excessive fatigue, of pain throughout the body, which would be increased by movement, and because of over-oxidation of nerve-substance there would be headache, nausea, and vomiting, and finally delirium, coma, and death. Just as occurs in cerebro-spinal meningitis, there would be a greater liability to succumb to the disease by those who overwork, or those who from any cause are depressed in spirits. Thin and spare persons of active minds would suffer most for the reason that they have less oxidizable material in reserve. There would be especial danger to those suffering from fear and anxiety. The disease would probably be neither contagious nor infectious, except through the over-work, mental anxiety, and grief attendant upon a fatal epidemic. There is one fact connected with the pathology of the disease in question that might receive explanation in this connection, that is, the excess of fibrin in the blood, which may be caused in some way through the oxidizing influence of ozone. The greater prevalence of the disease in the spring of the year may be capable of explanation by some facts concerning either the greater production of ozone at this season of the year, or by reason of there being a less consumption of ozone at such time in the oxidation of decomposing animal and vegetable matter. I have been thus particular to mention the supposed possibility of the production of this disease by an excess of ozone in the atmosphere, in the hope of stimulating observations concerning this agent. For several years I have made great effort to obtain a series of observations at different places throughout the State, and if such observations had been generally made and recorded throughout the State, and at the point where this epidemic occurred, it would doubtless have enabled us at this time to have answered this question of its being capable of contributing to the cause of this

epidemic. If the local board of health where this epidemic occurred had performed its duty promptly, and had given notice to this board immediately on the appearance of this epidemic, it is possible that the question might still have been answered at this time, for observation on ozone might then immediately have been begun, even if it required the continued presence of some agent of this board for that purpose. In the absence of evidence as to the relative amount of ozone in the atmosphere of that locality at that time, we can only mention it as possibly contributing, and express the hope that in the next epidemic we may be able to obtain exact information on this point.

SOME FACTS RELATIVE TO WATER SUPPLY.

The soil at Petersburg and Dundee is rather loose and sandy. Water upon its surface will pass quite freely through it. Organic impurities may not be so thoroughly removed from water by passing through this soil as through one containing more iron, or more clay through which it would pass more slowly. In this connection it should be stated that at Petersburg the cemetery is within the village limits. I was also informed that the most thickly settled part of the village was once an Indian burial ground. The bodies of those persons who died of unusual sickness just previous to this epidemic and who were said to have presented some of the symptoms of the disease in question, were buried in the village cemetery. The question arose as to the quality of the water drank by those who contracted cerebro-spinal meningitis.

The first well-marked case which was recognized at Petersburg was Frank Gunsolus, younger brother of a prominent physician of that place. He was taken sick March 3, 1874. The water supply of this family was obtained from a well on the premises. The water was particularly bright and sparkling, was said to be hard, and proved to be on trial, but gave me an impression of being soft water, and I now think it was because of the ammonia which it contained, as shown by the analysis made by Prof. Kedzie, and which will appear further on.

The next well-marked cases at Petersburg, were Chas. A. Boone and a boy named Pierce, both taken in a similar manner, at the same time, April 16th. Some of my notes, respecting the first of these boys, are as follows: Charles A. Boone, aged 12 years; slept up stairs until taken sick; wore flannel under-clothing; attended school; was active mentally. The day before he was taken sick he was made dizzy by playing "snap the whip;" was taken sick Friday morning, April 16th; was found about 2 A. M. vomiting and insensible. He was sick for a long time, and presented most of the symptoms usually found in this disease, including dilated pupils, retraction of the head, sensitive skin, great tenderness over spine and large nerves, dark spots, and in this case there was a marked discoloration of the skin over the course of the sciatic nerve, in the left leg, where the skin was exquisitely sensitive and looked as if it were about to slough off. The water used by him and his family for drinking and other purposes, was obtained from a spring on higher ground, but only 7 paces from the opening of two sewers, and 6 paces from a privy in the other direction. This spring was 5 paces from a house, and fifteen paces from the cemetery which is on ground from twelve to fifteen feet higher than the level of the spring. About 18 paces from the spring was a recent grave made May 24th, 1874. Water from this spring was also used by the family living in the house near by,—a rather old man and his wife, who appeared to be in their usual health. The Boone family had not always enjoyed good health since

they had lived here. The cellar of their house was not used, and was not in excellent condition. Mr. Boone informed me that he lately had some difficulty in obtaining good flour; had returned some that they could not well use. I endeavored to secure some of it for examination, but did not succeed in obtaining it. The following communication from Prof. Kedzie contains the facts revealed by analysis of the water from the two sources mentioned.

LANSING, Aug. 20, 1874.

H. B. BAKER, M. D., *Sec. of State Board of Health*:

DEAR DOCTOR—I have analyzed the specimen of water from the spring near the graveyard in Petersburg, and also the specimen of water from the well of Dr. Gunsolus in the same place.

From this examination I conclude that these waters are unfit for domestic use, and may be sources of serious disease in those who make use of them either as potable water or for domestic use. I do not base my conclusion on their physical appearance, for the spring water, while presenting a certain milky appearance at the spring, was bright and clear when it reached me, and the well water was beautifully bright and clear when I received it. The reasons for condemning these waters in a sanitary point of view arise from the chemical reactions which these waters exhibit, as shown in the following statement:

1. These waters contain an abnormal amount of chlorides in solution; the spring water contains chlorides equivalent to 356 parts of hydrochloric acid in 1,000,000 parts of water; while the well water contains 1019 parts in 1,000,000. The soil from which these waters are obtained is alluvial, and we cannot suppose that these chlorides are directly derived from the salt-bearing rocks which yield chlorides so abundantly in some parts of our State. The presence of a large amount of chlorides in water under such circumstances is usually attributed to "sewage contamination" by writers on hygiene, *i. e.*, to the presence of organic matter rich in chlorides.

2. These waters contain an unusual amount of ammonia: the spring water contains one part and the well water seven and a half parts in 1,000,000 of water.

3. These waters contain an abnormal amount of "albuminoid ammonia," that is, organic matter containing nitrogen, and which yields ammonia by putrefaction or by the action of oxidizing agents, *e. g.*, the permanganate of potassium. The spring water yields in 1,000,000 parts $1\frac{1}{2}$ parts of ammonia, and the well water 1.7 parts of ammonia when treated with caustic potash and permanganate of potassium, after all ammonia ready formed had been expelled by prolonged boiling with carbonate of sodium. This albuminoid ammonia is a most suspicious circumstance, as it reveals the presence of putrescible material in the water.

4. These waters contain a large amount of nitric acid in the form of a nitrate. The spring water contains in 1,000,000 parts 15 parts of nitric acid, and the well water 100 parts. This shows the presence of organic matter containing nitrogen which has become completely oxidized. While the nitrates may not be directly injurious to the human system, yet the presence of so large an amount of nitrates in water which contains putrescible nitrogenous matter is very suspicious.

5. These waters contain a startling amount of nitrous acid in the form of nitrites. The amount in quantity I am not able to state; but when Price's Test (pure Iodide of Potassium free from iodate, acetic acid, and gelatinized starch) is added to these waters without any concentration, they both become *deeply blue*. I never before found natural waters which gave so decided a reaction with Price's test. The presence of nitrous acid or nitrites is accepted by all hygienists as sufficient ground to reject any water for domestic use.

6. These waters contain very distinct traces of phosphoric acid. When a quart of water is evaporated to dryness, the residue dissolved in nitric acid, and excess of molybdate of ammonia added, a distinct yellow precipitate of phospho-molybdate of ammonia is formed. Phosphates are very seldom found in solution in natural waters. The alumina and oxide of iron in soils have so strong an affinity for phosphoric acids, that it will speedily withdraw it from solution by forming insoluble phosphates. That phosphates are found in solution in this water indicates that some organic matter, rich in phosphorus, is undergoing decomposition in such quantity that the soil is not able to completely withdraw it from solution.

The presence in these waters of unusual quantities of chlorides of ammonia, of albuminoid ammonia, of nitrates and nitrites, and finally of phosphates, shows these waters to be very unusual in their composition. We might account for the presence of all these substances if matters very rich in nitrogen and phosphorus, *e. g.* flesh, were undergoing decomposition in their vicinity and the results of this decomposition passed directly into this water. The fact that the spring is near and lies below the level of a graveyard, that the well is in the midst

of an old Indian graveyard, gives much plausibility to this explanation. The fact that the first person attacked with cerebro-spinal meningitis in Petersburg used the water of this well, and that others who used the spring water were attacked with the same disease, would very naturally attract very significant attention to the composition of these waters as having some possible connection with the terrible epidemic which has wasted that village.

Very respectfully,

R. C. KEDZIE.

Grouped in tabular form, the results obtained by Prof. Kedzie, appear as follows:

TABLE I.—*Exhibiting results of Analysis of Water from Spring near Cemetery, Petersburg, Michigan.*

IMPURITIES.	Parts in 1,000,000 of Water.
Hydrochloric acid.....	35.6
Ammonia.....	1.
Albuminoid ammonia.....	1.5
Nitric acid.....	15.
Nitrous acid, as nitrites.....	Unusual amount.
Phosphoric acid.....	Distinct traces.

TABLE II.—*Exhibiting results of Analysis of Water from Well on premises of Dr. Gunsolus, Petersburg, Michigan.*

IMPURITIES.	Parts in 1,000,000 of Water.
Hydrochloric acid.....	101.9
Ammonia.....	7.5
Albuminoid ammonia.....	1.7
Nitric acid.....	100.
Nitrous acid, as nitrites.....	Unusual amount.
Phosphoric acid.....	Distinct traces.

These two analyses were all that were made of drinking-water used by persons having the disease at this place, as they were about the only instances where the persons were still sick with the disease at the time I made the investigation. Frank Gunsolus has since died, after a sickness of some 149 days. When I last heard from the Boone boy he was convalescent. He had been sick about 80 days.

In talking with a gentleman in this city, whose wife was very sick with cerebro-spinal meningitis in the spring of 1873, he said she was taken sick "about the time the water in the well began to be bad in the spring." He was not sick at that time, but his work kept him away from home except at meal-times and nights. At Petersburg, however, several persons used water from the Gunsolus well and the spring near the graveyard, and did not have the disease. There has not yet been sufficient evidence collected on this point to warrant a definite opinion, but it seems quite possible that water containing

certain impurities may predispose persons to this, as well as to other forms of disease; and although healthy adults may sometimes use such water without serious results, it may have been one of the factors in bringing down the Boone boy, who was at the growing age, had eaten food made from bad flour, had an active mind, was using it at school, and took violent exercise the day before his sickness, probably attended with extreme changes in his bodily temperature. It may be that he could have endured any one of these conditions singly, but that taken altogether they made him sick. This was rather a typical case, except that it ended in recovery. Possibly, if other cases could have been studied as closely, a similar group of unfortunate conditions might have been found.

DOES THIS DISEASE DEPEND UPON ANY LOCAL ATMOSPHERIC CAUSE?

Ignoring the possible local influence of ozone, concerning which no evidence could be collected, a careful study of the local conditions actually found in connection with this epidemic, such as those of soil, sewerage, sources of malaria, and general and private sanitary conditions, does not reveal evidence of any influence capable of acting on the human system through the atmosphere, and which appeared to be so different from those in other localities where this disease did not exist, as to warrant the belief in its being the cause of this epidemic.

In this connection, there is one point which should receive attention hereafter. It was noticed in New York city that in the epidemic of 1872 the disease was at first almost entirely confined to original water courses. In studying the disease as it has been reported in the Vital Statistics of this State, I find that it is found more particularly in localities through which streams run. The epidemic of which this is a report occurred in villages situated along the bank of the River Raisin. Many of the inhabitants are inclined to attribute the disease to some influence from the river. If it was due to any such cause, it must have been one which does not ordinarily exist there, as this disease is extremely uncommon in that vicinity. There is one fact which may possibly be found to have some bearing upon the subject, so far as streams are concerned: it is that tons of the refuse from wheat ground at the various mills are annually thrown into the river. It is called "smut," but in ordinary seasons it consists largely of the fine velvety material from the small end of the kernels. In the year preceding that in which the disease prevailed along this river, the wheat and other grain raised in that vicinity was more than usually affected with what is called "smut," and the refuse from such wheat would contain vast numbers of the spores of the so-called smut,—a fungus known as *Tilletia caries*. Some of the mills were running during the winter and early spring months,—that was true of one at Norvell,—but as soon as spring fairly opened there was undoubtedly a great deal of this kind of organic matter present in the river water. It probably tended to collect in the sluggish bayous along the river banks, and as the warmer weather arrived it may have undergone decomposition and yielded a poisonous vapor to the atmosphere, or the living spores may have germinated. Milch cows may have drank it,—and they probably did so,—possibly with safety to themselves, but to the detriment of those who used their milk. These conjectures are all that can be brought forward now, as no knowledge of the epidemic came to this board until it was nearly over. But, given the two facts stated above, and the hypotheses are at

once suggested as of sufficient importance to warrant further examination, if, as is altogether probable, another epidemic shall give the opportunity.

This brings up another question somewhat closely related to this last. It is:

CAN THIS DISEASE BE CAUSED BY MILK FROM COWS FED ON POISONOUS FUNGI?

Edible fungi are sometimes poisonous when their spores are ripened. A case occurred in Scotland:

"Not long ago the Pharmaceutical Society in Edinburgh was promised a lecture by Mr. Sadler on edible and poisonous fungi, but when the evening came Mr. Sadler was ill. * * While preparing his lecture for the Pharmaceutical Society he accidentally swallowed a great quantity of the spores of a large species of puff-ball (*Lycoperdon Giganteum*), and within the space of an hour and a half was seized with severe illness, accompanied with violent pains. The violent symptoms were not subdued until nine days after the first attack. Sir Robert Christison, Dr. Balfour, and Dr. William Craig, who attended Mr. Sadler, were of the opinion that the continued irritation was kept up by the fungus spores. The giant puff-ball is edible in its young state, but its matured spores ought certainly to be avoided." *

It is well known that cerebro-spinal meningitis occurs most frequently in the winter and spring. At such seasons milch cows are fed largely on hay and ripened grain, while in summer their food is green, and, as a rule, spores of fungi may not be so generally ripened as in the winter and spring food. Whenever another opportunity is offered, it is to be hoped that the milk used by those who contract the disease will receive thorough microscopical and chemical examination, and that the food of the animals from which it is obtained will be closely examined. Mouldy hay would of course have thoroughly associated with it the spores of the particular fungus of which the mould consisted, and even these common moulds have been charged with poisoning.

Dr. M. L. Holbrook says:

"Johier has signalized the poisoning of three animals which had eaten mouldy bread. Westerhoff has made known the case of two children who had taken rye bread containing the *Mucor Mucedo*, the most common species of mould." †

Binding "rusty" straw is said to occasionally cause sickness.

Dr. Salisbury of Ohio claimed at one time that a disease something like measles could be produced by some fungus connected with straw.

Pavy mentions the production of diabetes by inhalation of spores in the dust of a "puff-ball." He has further found that "through the agency of the inhalation of puff-ball smoke an immediate and strong diabetic state may be induced, and that the effect is accompanied with such a modification of the circulation that the blood flows through the vessels as is the case after section of the sympathetic, without becoming properly de-arterialized. His experiments, he considers, suggest that in diabetes of the human subject, the blood, in consequence of vaso-muscular paralysis, is allowed to reach the portal vein in an imperfectly de-arterialized condition, and thus determines the escape of sugar from the liver." ‡

* Boston Jour. of Chemistry, Aug., 1874, p. 24.

† Page 181, "Eating for Strength."

‡ Lancet, Aug. 29, 1874. Quoted in "Medical News and Library, Oct., 1874, p. 156.

HOW DO FUNGI DESTROY ANIMAL AND VEGETABLE LIFE?

Without attempting to answer this difficult question, it may be proper to make a few suggestions regarding some of the possible methods of action of some fungi. Omitting, for the present at least, anything more than a reference to the directly poisonous action of the substance of some of them, by its action on the nervous system, the spores of some fungi, and perhaps the particles of germinal matter of which the spores are composed, may, and by some who have studied the subject are believed to be, capable of inducing changes within organisms analogous to those changes occurring outside of organisms which result in the production of the various alcohols, of vinegar, etc., etc., which are formed at the expense of more highly organized matter through a conversion of a part of it into the proper substance of the fungus. The same idea is applicable to those low forms of organic life which cause, or at least attend, those putrefactive changes in animal matter which liberate hydrocarbon or sulpho-hydrogen gases. These latter changes are believed to be connected with the presence of the lower forms of organic life, and the first-mentioned are accepted as resulting from a specific *vegetable* ferment in each particular case. Judging from the foregoing, taken in connection with the phenomena of the disease, we might expect to find that typhoid fever, for instance, may be caused by a low form of life capable of acting as a ferment or of reproduction at the expense of more highly organized matter. Remembering the peculiar "intoxication" in cerebro-spinal meningitis, we might also suspect that this disease, as also cholera, may be produced by a ferment or ferments of vegetable origin and character.

This is but an imperfect reference to a part of the subject which seems worthy of examination, but it was thought best to call attention to it, especially as this disease has been classed among zymotic diseases.

IS THIS DISEASE DUE TO INFECTION, BY MEANS OF FUNGI?

When certain fungi are found present in certain diseases, the question then arises whether they are the cause of the disease, or are dependent upon the diseased condition for a suitable soil in which to exist. This question seems to be already answered for some diseases. In small-pox, for instance, the condition requisite for the reproduction of the virus through implanting it in the system is not one of disease. The person must not only not be sick with small-pox, but must not have had the disease for some considerable time past. This is characteristic of the ferments. A ferment added to a solution which has just completely undergone the particular fermentation dependent upon such ferment produces no marked effect; but if added to a solution which is not fermenting, and has not undergone such fermentation, if the solution contain material capable of maintaining such fermentation, it will go through such changes if under suitable conditions of temperature, etc. The uniformity with which these phenomena present themselves is so generally understood as hardly to require proof. Every housekeeper who raises bread with yeast can certify that the fermentation appears to depend upon the *yeast*, and that the quantity of yeast is increased in this way. Knowing this uniform mode of action of ferments, whether within or without the body, the explanation of the regular course of the contagious diseases and of the reason why they do not, as a rule, appear but once in the same person, does not seem difficult to understand. Now that we know this characteristic action of ferments, and know that the virus of vaccine and of small-pox consists of "living and inde-

pendent organisms, belonging to the smallest and simplest of all living things, which multiply, without the formation of mycelium, by cell-division alone, and perhaps by the production of resting-spores,"* it seems reasonable to expect that the other contagious or infectious self-limited and self-excluding diseases will also be found to depend upon the introduction into the system of a particular ferment which causes each disease, and that thorough and systematic search will reveal the precise nature of each one of these special ferments. As regards that of small-pox, "according to Dr. Cohn's observations, these corpuscles are single cells of a spherical form, not more than one twenty-five thousandth of an inch in diameter. They belong to the genus *Micrococcus*, and those of the vaccine lymph are designated by the name of *Micrococcus Vaccinæ*. They increase in numbers if kept at the temperature of the living body, forming chains and groups of associated articulations."†

There is additional encouragement in the search for these specific ferments, in the fact that already "another kind of micrococcus has been described by Dr. Oertel of Vienna, and by Prof. Ebert of Zurich, as constantly present in cases of diphtheria; and both observers have found that its inoculation in different parts of the body in healthy animals produces a diphtheritic malady having its starting-point at the place of inoculation."†

The existence of fungi or other parasites as the cause of disease is not necessarily negatived by the fact of a disease being continuous. The *Achorion Schonleinu* is capable of continuously maintaining itself and thereby the peculiar disease known as favus. It seems probable that in order that diseases dependent upon fungi shall run a definite course and protect against future attacks, the fungus must undergo its changes in the blood of the patient, and the disease be a general one, causing a change throughout the whole organism. In cerebro-spinal meningitis the disease seems to be dependent upon some blood-poison and, considering the usual phenomena of fermentation and of diseases dependent upon special ferments, it would seem that a very important question to be asked in the study of the cause of this disease, is as to whether it both runs a regular course and is protective against future attacks of the same disease. Although individual cases of cerebro-spinal meningitis present considerable variations, there still appears to be a greater tendency to death at certain stages of the disease, and a certain change in the symptoms of the disease after a certain period in its progress. But this alone, without protective influences, does not indicate whether or not the disease is due to a specific ferment, for the symptoms may be the same whether the blood-poison be a ferment or a simple mineral or vegetable poison. On the question of protection against future attacks of the same disease, it seems almost impossible to obtain any data, for the reason that the outbreaks of this disease occur so erratically. One might nearly as well inquire whether lightning ever strikes twice in the same place. Without this kind of data we lack important evidence of its being caused by a specific ferment. Inasmuch as no such ferment has ever been discovered in connection with this disease, we must conclude that we have not as yet satisfactory evidence on this point. Unless it can be proved that the disease is due to an ordinary poison, it is to be hoped that observers will endeavor to collect evidence of its protective influence, and search

* Dr. Cohn, quoted by Prof. John C. Dalton, M. D., in Address on the Origin and Propagation of Disease, Am. Chemist, Apr., 1874, p. 380.

† Prof. J. C. Dalton, in Address on the Origin and Propagation of Disease, Am. Chemist, April, 1874.

for the presence of a specific zymotic cause. Evidence as to its communicability by infection should also be sought for.

FEAR is frequently an important element in the causation of spinal congestion. The following evidence bears upon its influence in this disease: Dr. Gunsolus of Petersburg tells me that Mr. Gradolph was very apprehensive on the subject of cerebro-spinal meningitis during its prevalence there. His brother-in-law,—Mr. Harvey,—also expressed fear that he should contract the disease. One little girl more than once went home from school to her mother, and, putting her hands up to her mother's face, said, "I am not feverish, am I mother? I am not going to have the fever." Another little girl, some time before coming down with the fever, said she knew she should have the disease,—she was sure she should catch it. All these persons contracted the disease and died. It may be that in such cases the fear is partly due to effects of the poison of the disease not yet sufficiently powerful to produce its full effect; but there can be no doubt but that fear is capable of causing serious disturbance in the circulation, and it may be, and probably sometimes is, a factor in the cause of this disease.

Just how such impressions upon the nervous system tend toward the production of this disease may be made to appear more evident further on, after studying some more powerful exciters of vaso-motor nerves.

SEASON OF YEAR.

Dr. Aitken, in his *Science and Practice of Medicine*, says:

"Of 182 European epidemics, 24 were in October and November, 46 in December and January, 48 in February and March, 30 in April and May, 24 in June and July, and 10 in August and September (Simon).

The outbreaks in this country have been chiefly during the winter and early spring. In Sweden, of 417 local outbreaks, 311 were in winter and 106 in summer. Of 85 epidemics in Europe and the United States, noted by Hirsch, 33 prevailed in winter, 24 in winter and spring, 11 in spring, 1 in spring and summer, 2 in summer, 1 in summer and autumn, 1 in autumn, 1 in autumn and winter, 3 in autumn, winter, and spring, and 6 throughout the whole year."*

The epidemic concerning which this is a report, occurred in the spring of the year.

Difference in temperature is perhaps the most prominent fact connected with the seasons of the year. But because a large proportion of epidemics occur in winter and spring it does not necessarily follow that they are due entirely to the temperature. The food is somewhat different at different seasons, and there are other conditions which cannot properly be ignored, although temperature may be considered first.

COLD AND CHANGES IN TEMPERATURE.

Is this disease due primarily to some external influence exerted upon the nervous system? Of such influences, heat and cold are among the most prominent. It is believed that the influences of heat and cold are sufficient to cause spinal anæmia and spinal congestion. It is claimed, but not proved, that these influences in connection with a wound are sufficient to cause tetanus. In some respects these diseases are similar to the one in question. There is, however, a general belief that something more than unusual conditions of heat

* Vol. II., p. 455.

and cold are required for the production of epidemic cerebro-spinal meningitis.

But temperature is a subject too important to be dismissed without an effort to learn the nature of its action upon the living body. Can the nature of the action of cold be explained?

Cold is one of the causes to which tetanus is attributed. Torticollis (wry neck) is believed to result from exposure of the part to cold. Most people who, during a cold winter day, have ridden a long distance, exposed to a cold atmosphere, in an open vehicle, have also experienced a peculiar stiffness of the muscles of the neck, with more or less difficulty of turning the neck from side to side. Swimmers are quite frequently taken with cramp while exposed to the influence of cold in the water. The action of cold in contracting the surface of the body, making it to appear like "goose flesh," is well known. Living human tissue subjected to extreme cold, is comparatively pale and bloodless. From this grouping of facts, it would seem that one prominent action of cold is to cause tonic (tetanoid?) contractions of muscular tissue; and this action is not confined to non-striated muscles. This appears to be the explanation of the phenomena mentioned above.

The fact that such muscular action is caused by cold is important, and should not be overlooked in studying the cause of this disease. Tetanoid contractions are so common in this disease that it has been proposed to change the name to "Tetanoid Fever." We see from the foregoing that, within the limits of our ordinary experiences, cold is known to produce cramps and contractions which are essentially tetanoid. The subject of tetanoid contractions will be studied more at length in another part of this paper. The following facts in physiology and anatomy may also be profitably considered in this connection, as also for their bearing upon the subject of disturbance of the circulation in cerebro-spinal meningitis.

"From all of these observations, and others of the same kind which we have not thought it necessary to quote, the existence of vaso-motor nerves and their connection with centres in the cerebro-spinal axis are sufficiently well established. It is certain, also, that centres presiding over particular functions may be located, as the genito-spinal centre, in the spinal cord opposite the fourth lumbar vertebra, and the cilio-spinal centre, in the cervical region of the cord, both described by Budge. A stimulus generated in these centres, sometimes as the result of impressions received through the nerves of general sensibility, produces contraction of the non-striated muscular fibres of the iris, vasa deferentia, etc., including the muscular walls of the blood-vessels. The contraction of the muscular walls of the vessels is tonic; and when their nerves are divided relaxation takes place, and the vessels are dilated by the pressure of blood. By this action the local circulations are regulated in accordance with impressions made on sensory nerves, the physiological requirements of certain parts, mental emotions, etc. Secretion, the peristaltic movements of the alimentary canal, the movements of the iris, etc., are influenced in this way."*

As shown in the foregoing quotation, the circulation is controlled through the influence of vaso-motor nerves, and "local circulations are regulated in accordance with impressions made on sensory nerves," etc. It may thus be understood how cold may powerfully influence the circulation. We may

* Flint's Physiology, Vol. IV., pp. 438-9.

notice in passing that Prof. Flint says, "the movements of the iris, etc., are influenced in this way," that is, through the same system of nerves which controls the circulation. Disturbed movement of the iris, particularly dilatation, is a common occurrence in this disease. One fact relative to the circulation in this disease is that the pulsations of the heart are sometimes lessened in frequency, a condition not usually found in other fevers, and which may be due to irritation of the pneumogastric or the spinal accessory nerves.

"All that can be said, in the present state of our knowledge, is, that the pneumogastrics have a direct inhibitory influence on the heart. When they are divided and the heart removed from their influence, the pulsations become more rapid. When the peripheral ends of the divided ends are galvanized the heart beats more slowly, or its action may be arrested by a current of sufficient power. This action may also be reflex, due to an impression conveyed to the centres by what have been described by the brothers Cyon and Ludwig, as the depressor nerves." *

"When the central ends were stimulated in dogs the pupils became dilated, the eyes protruded, sometimes vomiting occurred, and always the number of respiratory acts was diminished, and, with a powerful current, were arrested in inspiration; but the pulsations of the heart were not affected." †

If the phenomena attending irritation of both extremities of this nerve be grouped together, more of the phenomena sometimes present in cerebro-spinal meningitis appear than when taking them separately. In the living person, any stimulation of such nerves at their roots or near the medulla oblongata would be equivalent not simply to stimulating either the peripheral or central ends, but both peripheral and central ends. This bears more particularly upon a part of the subject treated of further on, namely the influence of substances in the food which may enter the blood, act upon the vaso-motor nerves to control the circulation, and, by so doing, cause serious damage to the cerebro-spinal nervous tissue. But these considerations also have a bearing in this connection; for it seems that the circulation may also be influenced by cold; and in this connection I desire to call attention to a fact which may be of importance as an aid in appreciating the manner in which cold may cause serious trouble. This fact is, that when a person is exposed to a cold atmosphere nearly every part of the body is protected by warm clothing, but *the cold atmosphere is inhaled into the lungs at every breath*. This is also true at night, when a person is sleeping in a warm bed, in a cold room. It is an important question which remains to be proved, whether or not this fact has any necessary connection with such other facts as that epidemics of cerebro-spinal meningitis occur more frequently in cold weather, that persons affected with the disease complain of pain in the back of the head and neck, which pain is increased by movement of the neck, especially forward, that the pupils are dilated, and that in the beginning of the disease vomiting is a frequent occurrence. Some of the prominent phenomena of this disease, such as tetanoid contractions of the muscles, are such as may be accounted for by the influence of cold, while some of the other phenomena would be accounted for by irritation of the pneumogastric nerves. These nerves are distributed mainly to the lungs, the heart, and the stomach. Cold air taken into the lungs would furnish both the conditions just mentioned.

* Flint's Physiology, Vol. IV., p. 233.

† Flint's Physiology, Vol. IV., p. 225.

That cold is one of the causes of this disease appears probable. That it is the most important cause seems improbable. If it were, the disease should appear in every cold season. It does not; and what is more, it sometimes appears in summer and autumn, in seasons when cold could not be supposed to account for its prevalence.

DRYNESS OF THE ATMOSPHERE.

In a brief sketch of this disease as it appeared in Livingston Co., Mo., in the winter of 1861-2, Dr. T. F. Prewitt mentions (*St. Louis Med. and Surg. Journal*, May and June, 1865,) that it "first made its appearance among the soldiers stationed at Chillicothe, during an unusually severe and protracted spell of dry cold weather." *

In speaking of the epidemic which began in New York city about the beginning of the year 1872, Dr. Moreau Morris says:

"In this connection, with reference to the present epidemic, an investigation of the meteorological conditions immediately preceding its outbreak exhibits the fact that, during the last three months of 1871 and the first three months of 1872, there had been comparatively with the corresponding six months of ten previous years, a very unusual and marked dryness of the atmosphere; and when we remember that this disease began to develop coincident with the lowest point of humidity, and rapidly increased during that dry state of the atmosphere, we may, perhaps, recognize an element having a most important bearing upon the question." †

This subject should receive attention. It may turn out, however, that the dryness as well as the disease is closely connected with extreme cold, and in a great degree dependent upon the temperature.

POISON IN FOOD AS A CAUSE OF THIS DISEASE.

Next to atmospheric influences, the most constant and controlling in their action are those of food and drink. A careful study of the literature of this disease makes it apparent that it has at various times prevailed, under very different circumstances, in localities subject to malaria, and in those not subject to it, in one locality at one time and in another near by at another time. The evidence is not conclusive that it is contagious; it attacks persons of both sexes and at all ages. Now some injurious article of food, or some temporary quality of the water supply of a locality might account for this irregular appearance of the disease.

Taking up the question of food, we know that frequently the main articles of food of a given locality are the same for a large proportion of the inhabitants. The flour that supplies a locality with material for its breadstuffs is generally supplied in considerable quantities from one source. Any poisonous ingredient in it would be distributed to all persons alike, leaving those most susceptible to its influences to suffer most.

There are certain facts connected with outbreaks of the disease in foreign countries which point strongly to some poison in the food as the cause of epidemic cerebro-spinal meningitis. Dr. J. Netten Radcliff says: ‡

"During the outbreak in France in 1837 and following years, the ravages of the malady were principally confined to certain garrisons, and even to small

* Am. Jour. Med. Sci., p. 278.

† Report, Board of Health of New York City, 1871, p. 254.

‡ Epidemic Cerebro-Spinal Meningitis, by J. Netten Radcliffe.

sections of a garrison, without affecting the surrounding population. A like limitation of the disease to certain detachments of troops was observed during the recent war in the United States; and the restriction of the malady to small portions of workhouse populations, as in the first outbreak in Ireland, is an analogous phenomenon." "In France, from 1838 to 1848, the disease re-appeared again and again among the forces in Bayonne, Versailles, and Avignon, *notwithstanding changes of garrison.*" "During 1837 and 1838 the garrisons of Bayonne, Dax, Bordeaux, Rochefort, and La Rochelle suffered. From 1838 to 1841 the disease was prevalent among the garrisons of northeastern France, particularly those of the valley of the Rhone. Thus it broke out at Toulon, Marseilles, Aigues-Mortes, Nismes, Avignon, and Pont-Saint-Espirit. In the course of the four years, 1839-40-41-42, the malady appeared in succession among the troops occupying the fortresses of Strasburg, Schelestadt, Colmar, Nancy, Metz, and Givet." "From 1839 to 1842 [*same years as above*] it prevailed among the forces at Versailles, Saint Cloud, Rambouillet, and Chartres." "Those stationed along the coast of Brittany, at Brest, L'Orient, Nantes, and Ancenis, suffered in 1841; and during 1840 and 1841 *the disease manifested itself among divers detachments of a regiment scattered at Laval, Le Mans, Château-Goutier, Tours, and Poitiers.*" "In 1840 *it broke out among the French garrison at Donera, Algeria*, and during the next seven years it attacked numerous towns and localities of the province, affecting the civil population, both European and native, as well as the military." "During 1849 and 1850 the disease was prevalent to some extent among the French troops in Italy."

Speaking of the outbreak in Ireland in 1866, the same writer remarks:

"It is noteworthy that, as in the earlier outbreaks in France, the military in Ireland, in proportion to their strength, suffered prominently from the disease. In some of the country districts cases were recorded among the troops alone, or among persons in immediate connection with them." "In January and February, 1867, an outbreak of a disease characterized by severe rigors, tetanic convulsions, intense neuralgic pain in the head and upper part of the trunk, increased sensitiveness of the surface, obstinate vomiting, restlessness, and, in one instance at least, by a dark purple eruption, but of which not a single case died, took place at Bardney, in Lincolnshire, a village about ten miles east of Lincoln, on the verge of a fen country, and having a population of 1,500, the bulk of whom are engaged in agricultural pursuits."*

One can hardly study these facts without coming to the conclusion that in the cases mentioned the disease as it occurred in the armies was produced by some article of army supply furnished to troops. There would not be likely to be any peculiarity of the water supply which should affect troops so much more generally than the surrounding population. Atmospheric influences would not be likely to be so restricted, except through defective ventilation, and this does not seem capable of explaining all the epidemics that have occurred, particularly as it occurs in localities where the ventilation is the same as previously, and as after the disease has disappeared. The disease does not appear to be contagious, and the evidences exhibited of infection of localities are not prominent except as connected with troops. It seems probable that the disease was caused by some article supplied to the troops, only in those years, or which only had deleterious power sufficient to cause the disease in those years. Unless evidence can be produced of some unusual supply to the troops

* Quoted from "Epidemic Cerebro-Spinal Meningitis," by J. Netten Radcliffe, as are preceding statements of epidemics among garrisons.

at that time, it remains to conclude that the cause was perhaps due to some temporary quality of the usual food. This would be a cause capable of explaining the facts, and no other cause which has been suggested would so well account for all of them. Some of the prominent facts relative to the epidemic just mentioned may be briefly recapitulated as follows: In France, in Ireland, and in the United States, at different times, the disease was principally confined to garrisons and detachments of troops. In the years 1837 to 1842 the disease attacked the French troops, and in two instances while serving abroad. In one instance, also, the troops of a particular regiment suffered, although scattered about in different localities. Now it is quite probable that the commissary supply of that regiment may have been the same for all its several detachments, and quite possible that it was in part the same as furnished to those garrisons and detachments at home and abroad, which suffered from this disease. In order that this should be true, however, the article causing the disease must have been one which was uniformly used in small quantities, purchased in large quantities, or one which was the product of some crop which was affected throughout wide areas of production, as, for instance, the wheat crop, which may have been unusually affected during those years, in which case a larger proportion of affected grain may have found its way into the breadstuffs supplied to the troops than was retained by the agriculturists for their own use.

If those epidemics in France in the years 1837 to 1842 were due to such a cause, it is somewhat singular that they were not traced out at the time, for I find accounts of several serious epidemics which in times long past have occurred in France and in other countries, and which were believed to be due to ergotism; and on page 486, Vol. I., Chapin's Therapeutics, published in 1825, the author says: "It has been a generally received opinion in Europe for a century or two, that bread made of grain vitiated in this way, occasions diseases of a very extensive and violent description. Of these, however, the most common is a species of dry gangrene, pervading at the same time entire districts of country." In a footnote referring to the possibility of such diseases being caused in this manner, the same author says: "This is no longer doubtful. By a series of well-conducted experiments, Dr. Charles Byrd has shown that pigs, ducks, and fowls, eating for a week or two food containing the ergot, acquire a gangrenous state by which the former lose their hoofs and the latter their bills, etc. These experiments are contained in his Inaugural Essay, 1821." On page 628 of Coxe's American Dispensatory, published in 1831, is an extract from this same inaugural essay of Dr. Charles Byrd of Virginia, giving some further details of his experiments. He says: "From the results of my own experiments, I am led to the certain conclusion that the ergot is capable of producing the dry gangrene; but at the same time I am convinced, and indeed the fact is mentioned by M. Bossau that the gangrene is not always of the dry kind, which certainly is proved by my last experiment." In the extracts from this essay which I have found, the prominent symptoms of cerebro-spinal meningitis do not appear, but this experimenter seems to have been looking mainly for certain symptoms which had been mentioned in connection with this cause, and he may have overlooked many of the actual results. In fact it is certain that he either overlooked some of the results, or the poison is capable of producing different effects under different circumstances. His experiments were with animals. The effects of ergot of rye on human beings are stated on page 382 of the U. S. Dispensatory of 1870,

as follows: "In the quantity of half a drachm or a drachm it often occasions nausea or vomiting, and in still larger doses produces a sense of weight and pain in the head, giddiness, dilatation of the pupils, delirium, and even stupor." Now these, so far as they go, are precisely the symptoms exhibited in cerebro-spinal meningitis.

In an article on Epidemic Cerebro-Spinal Meningitis, by J. Netton Radcliffe, in J. Russell Reynolds' System of Medicine, I find the following:

"Diseased Grain.—Dr. B. W. Richardson has suggested that epidemic cerebro-spinal meningitis may possibly arise from the consumption of diseased grain, after the manner of ergotism, and perhaps acrodynia. He thinks the probabilities are altogether in favor of the suggestion, that 'the cause, in fact, is a diseased grain, or fungus, contained in some kinds of flour out of which the breadstuffs are made. This fungus may not be present in large quantities, and many persons may eat of the food without getting a poisonous part; but one will get it out of a number, and this without any communication beyond the breaking of bread together. The disease may occur in one member of a family, leaving the rest free; and in this irregular way it may be distributed in an epidemic form over a large surface of the country.' He adds: 'If my hypothesis, as regards cause, be correct, there is little danger of the disorder extending widely in this country; for of our cereals used as food, nearly the whole of the population now select wheat, and our wheat generally is selected for the market with great judgment and circumspection. Any cases, therefore, that might occur would be isolated, and would be easily traced out and prevented.'¹ This suggestion opens out an altogether new field of inquiry respecting the origin of the disease, and it demands active and thoughtful consideration in subsequent outbreaks. Dr. H. Day of Stafford has endeavored by experiments on the lower animals to obtain some light on the subject. He fed three rabbits with unsound grain (wheat, oats, ergot of rye, and mouldy bread) with this result: In all the animals a spasmodic affection was produced, and in two inflammatory changes in the right eye, proceeding in one case to ulceration of the cornea and evacuation of the contents of the globe. One of the rabbits died on the eighth day, the other two were killed on the twelfth day, and in all more or less congestion of the membrane of the spinal cord was found on dissection.'²"

SOME EFFECTS OF ERGOT.

The following quotation from Wood's Therapeutics, is a description of some of the effects of ergot; but omitting such words as "dose," "drachm," etc., it might well pass for a description of the symptoms present in many mild cases of cerebro-spinal meningitis. It should be borne in mind that the author is describing the effects of ergot in doses insufficient to cause death:

"If the dose be increased to half a drachm or a drachm it will, in both sexes, occasion some degree of nausea, and more or less cerebral disturbance, attended, generally, with some diminution in the frequency and force of the pulse. In still larger doses, of from one to two drachms or more, it evinces decided narcotic properties. With nausea and a disposition to vomit, and sometimes actual vomiting, there are now dilatation of the pupils, giddiness, a feeling as of intoxication, heaviness or pain in the head, and not unfrequently more or less drowsiness or stupor. Sometimes irregular and involuntary

¹ Social Science Review, May, 1865, p. 403.

² Clinical Histories and Comments, pp. 18-23.

muscular contractions have been noticed; but they are not common symptoms. The dilatation of the pupil is an ordinary phenomenon. It is usually, however, moderate, and unattended with disorder of vision. Sometimes the bowels are disturbed, and evidences of gastro-intestinal irritation or inflammation are said to have been presented in some instances; but this is certainly not a necessary or even common result. Sensations of itching, numbness, or fatigue, are occasionally felt in the limbs. The circulation is usually depressed, and sometimes greatly so. In female subjects, the uterine contractions are induced much more quickly than the nervous symptoms here described, and do not continue so long. What dose would be sufficient to prove fatal in man has not been ascertained; nor can I find that any instance of death has been traced to a single dose, however large.”*

ERGOT HAS BEEN USED AS A REMEDY.—MAY IT BE A CAUSE OF THE DISEASE?

Ergot has been recommended and used for the treatment of this disease, and it is believed by some that it is useful for this purpose. This being true, it is quite probable that some will be inclined to reject, without any examination whatever, the idea of the disease being caused by ergot or by a fungus similar to ergot. It may therefore be worth while to show that, instead of being opposed to such idea, the fact may, possibly, be explained in a way to support that view.

It is well known that after the long-continued application of cold to the human body it is entirely unsafe to allow the body to be subjected to the action of heat, even that borne under ordinary circumstances. In the case of chilled fingers, it is considered good practice to apply snow, and, afterwards, cold water, and only to allow the temperature of the part to increase very slowly, in order to avoid too violent reaction, which has been found dangerous. We may also bear in mind the proposition that “action and re-action are equal and opposite.”

Cold is believed to cause the contraction of non-striated muscular tissue, and thereby lessen the calibre of the blood-vessels and the supply of blood to the parts. The influence of heat in an opposite direction is well known. Heat and cold have been recognized as sufficient to cause spinal congestion. From what we know of such influences in other parts of the body, we may assume that alternations of heat and cold would be a much more efficient cause. If there were brought to us a patient whose whole body had been subjected to extreme cold, we would expect that his nervous system, or other tender parts of his body, would be in great danger if we immediately allowed him to be subjected to the influence of heat. We would expect the best result from the application, at first, of cold, that is, compared with normal temperatures.

Ergot is also believed to cause contraction of the non-striated muscular tissue of the body generally, as it is known to do in the uterus, and as it does in the blood-vessels when it restrains hemorrhage. Now it seems quite possible that the long-continued use of flour made from ergotted rye or smut wheat may produce a condition of the system somewhat analogous to that produced by extreme cold, and that whenever a person previously subjected to such food is suddenly exposed to heat or any other such influences as tend to relax non-striated muscular tissue, that person is in danger from congestion, and espe-

* Wood's Therapeutics and Pharmacology, Vol. II., pp. 693-9.

cially from congestion of those parts which soonest feel the influence of such relaxation. It *may* be just as dangerous to suddenly withhold ergot, after its long-continued use, as it is to suddenly expose a person to heat after long-continued exposure to cold; and, possibly, for very much the same reason.

That ergot has seemed to be useful in certain stages of this disease does not therefore necessarily weaken, but it may rather strengthen the view that the disease may be caused by a similar fungus.

A large number of epidemics of cerebro-spinal meningitis occur,—as did the one reported in this article,—in the spring of the year, when we have a cessation of the cold winter weather. It is also well known that ergot loses its power by age, and it is possible that the same flour which has during the cold weather contained ergot or smut of rye, buckwheat, or wheat, in an active form, may as spring comes on lose some of its active power over non-striated muscular tissue. If this should be found to be true, then the explanation of the manner in which this disease might be caused by ergot would not be much more difficult than the explanation of congestion resulting from sudden exposure of a part to heat that had previously been subjected to cold. In the spring of the year the influence of heat following cold would be added to the other cause or causes more generally than at any other season of the year, except perhaps in winter, when the cold is usually present out of doors and the heat indoors, and alternations of temperature are as rapid as the passage from one place to the other. This may account for the fact that epidemics of this disease have been most frequent in the first half of the year.

There is another fact capable of a similar explanation. That is the frequent onset of this disease during sleep. In studying the epidemic at Petersburg this fact was more than once mentioned, and in looking over histories of cases elsewhere I have frequently observed that the first knowledge of the disease appeared at night, after the person had retired, the patient being awakened by nausea or vomiting, or being found in distress by others. Here the influence of a warm bed would be one element in the case; the position of the body is another, and, it may be, a stronger one. "In the recumbent posture on the back, the blood gravitates in large amounts to the spinal vessels." *

And, again, the relaxation of tissue in sleep, dependent upon suspension of active stimulation of the cerebro-spinal system of nerves, probably favors that stagnation of blood from diminished tonicity of the blood-vessels, whether caused by heat following cold, or by a lack of other accustomed stimulus to their muscular walls, such, for instance, as might result from a change from the use of food containing ergot to that containing none.

Prof. Flint says: "The contraction of the muscular walls of the blood-vessels is tonic; and when their nerves are divided, relaxation takes place, and the vessels are dilated by the pressure of blood." * * * "The vaso-motor filaments are not confined to the branches of the sympathetic, but they exist as well in the ordinary cerebro-spinal nerves." †

The foregoing is offered in order to induce certain persons to investigate this subject. To the writer it seems fully as probable that the disease may be caused by the direct action of ergot or other fungi, in conjunction with cold, as will appear further on. There are, however, at least two classes of cases.

* Diseases of the Nervous System—Hammond, p. 392.

† "Physiology of Man," by Austin Flint, Jr., M. D., p. 439.

THE PRODUCTION OF TETANOID CONTRACTIONS.

One of the most prominent phenomena of cerebro-spinal meningitis is the tetanoid contraction of muscles, more particularly those of the neck and back. It is therefore important to learn, if possible, how such contractions are produced.

Strychnia is a substance which, if taken into the blood, is capable of causing tetanoid contractions. It seems to be generally believed that strychnia produces its effects by its action upon the nervous centres of the spinal marrow. Tetanus, also, "is generally admitted to have its essential seat in the spinal marrow." *

Hydrophobia is another example of tetanoid convulsions now attributed to an affection of the spinal cord. A course of reasoning similar to that which has led to the belief that strychnia produces its effects through the nervous centres of the cord, leads to the opinion that the tetanoid contractions which occur in cerebro-spinal meningitis are due to the action of a blood-poison or of mechanical pressure upon the cerebro-spinal nervous centres. May not the production of all tetanoid contractions be reduced to a general law of method?

In reference to tetanoid symptoms in this disease, Dr. Stillé says: "Their presence unequivocally denotes the existence of spinal lesions." † His view seems to be that they are due to either inflammation or congestion; but tetanoid contractions occur in non-striated muscular tissue through irritation of sympathetic or vaso-motor nerves; and it seems possible that they may occur in other muscles through irritation of cerebro-spinal nervous centres, without inflammation or even congestion.

May not these phenomena of pathology be explained in accordance with recognized phenomena in physiology? Prof. Flint says:

"Taking into consideration the most reliable direct observations upon the sympathetic ganglia and nerves, the fact that their stimulation induces movements in the non-striated muscles to which they are distributed can hardly be doubted. This action is particularly well marked in the muscular coat of the blood-vessels; but here the function of the nerves is so important that it merits special consideration, and will be treated of fully under the head of the vaso-motor nerves. The mechanism of these movements, however, is peculiar. *The action does not immediately follow the stimulation, as it does in the case of the cerebro-spinal nerves and the striated muscles, but is induced gradually, beginning a few seconds after the irritation, endures for a time, and is more or less tetanic.*" ‡

"This mode of action is peculiar to the sympathetic nerves and the non-striated muscular fibres." §

Now such action may be peculiar to the sympathetic nerves and to non-striated muscles, so far as physiological action is concerned. Voluntary (striated) muscles may not physiologically act in that manner; but in such pathological states as those of tetanus, cramp, cholera, and the opisthotonos of cerebro-spinal meningitis, voluntary muscles do act in such manner. In tetanus the gradually increasing and continuous contraction goes on, in some cases, until the striated muscle is ruptured by its own contractile force, which even then

* Wood's Therapeutics, Vol. I., p. 523.

† Stillé on Epidemic Meningitis, p. 33.

‡ Italics mine.

§ Legros et Onimus, De la contraction des muscles de la vie vegetative, Journal de l'Anatomie, Paris, 1869, tome VI., p. 433.

§ Austin Flint, Jr., M. D., Physiology, pp. 428-9.

is not abated. In cerebro-spinal meningitis the retraction of the head is sometimes so powerful and continuous that, if the patient be so placed, he will rest only upon the back of the head and the heels. So far as is known to me, there has not been offered any explanation of the physiological or pathological mechanism of such action as this. But if the view of Valentin and Prof. Kolliker as to the non-specific character of the sympathetic nerves be accepted, the explanation does not seem difficult.

"Allowing that the great number of very fine pale fibres in the sympathetic is a prominent anatomical fact, as is also, indeed, the case in the higher nerves of sense and in the gray substance, still, speaking physiologically, I am by no means of opinion that the fineness of the fibres in the sympathetic indicates anything of a special nature in them, and which does not exist elsewhere; but, perhaps, that where this condition does exist, both in them and in other situations, it is connected with a distinct kind of function."*

In this connection it seems important to bear in mind, that apparently just such action as is caused in non-striated muscles, by stimulation of sympathetic nerves, occurs in striated muscles during tetanoid contractions, and apparently by stimulation of either the nerves as they enter the muscle, the muscular tissue itself, or, what seems most probable, those finer fibres in the substance of the spinal cord which Prof. Kolliker seems to believe to be anatomically the same as sympathetic nerves, and "connected with a distinct kind of function."

If it be admitted that direct stimulation, or irritation of nervous centres of the spinal cord may cause tetanoid contractions of striated, so-called voluntary muscles, the conception may be of very great importance in the study of the nature of the causes not only of cerebro-spinal meningitis, but of all that class of diseases which manifest tetanoid symptoms; such as tetanus itself, hydrophobia, cholera, etc. The phenomena attendant upon poisoning by strychnia seem to be capable of explanation in accordance with this view. This substance is absorbed into the blood, and circulates through the tissues. It causes simultaneous tetanoid contractions of different striated muscles supplied with spinal nerves, and when it is excreted from the body, such contractions cease. As stated by most authors, the contractions are probably due to the influence of the drug upon the spinal centres. Dr. Brown-Séquard has expressed the opinion that strychnia has the power of stimulating the nervous centres of the spinal cord "independently of the quantity of blood which it contains."† According to Stillé, it also augments the tone of the muscular coat of the bowels and bladder. "In like manner it is reported to excite uterine contractions."‡ It appears, therefore, to act upon the non-striated as well as the striated muscular tissue. If the direct irritation of the spinal centres, by substances in the blood, can cause action of striated muscles supplied with nerves from that source, similar to that caused in non-striated muscles by irritation of the sympathetic nerves of the part, then the fact is entirely in harmony with the view of Kolliker, that the nerves in the two situations are anatomically the same, and we would expect that substances capable of acting upon non-striated muscles through the sympathetic nerves, if applied as a blood poison would be, directly to the cerebro-spinal centres, would produce

* Kolliker's "Microscopical Anatomy," p. 423.

† Stillé Therap. & Materia Medica, Vol. II., p. 151.

‡ Stillé Therap. & Materia Medica, Vol. II., p. 152.

somewhat similar effects in the striated muscles supplied with nerves from the cerebro-spinal centres.

But, of the *post-mortem* appearances in poisoning by strychnia, "congestion of the membranes of the brain and spinal marrow is probably the most common,"* and the tetanic contractions may be largely due to mechanical pressure and irritation of the nervous tissue.

It seems proper to look for the cause of the tetanoid contractions in cerebro-spinal meningitis among those agents which have been known to produce such results. There is no evidence that it is due to strychnia. There is evidence that leads to the belief that cold is a factor, but it also seems probable that it is only a factor, and that there is some other cause, and perhaps a more important one. Next to the two just mentioned, one of the most powerful causes of contraction in non-striated muscular tissue is ergot. If given in sufficient quantity, and continued sufficiently long, may not ergot stimulate to contraction voluntary as well as involuntary muscles? May it not act upon the cerebro-spinal nervous centres in the same way that it is known to act upon the sympathetic and vaso-motor nerves? † For our present purposes an affirmative answer to this question is not essential, for congestion of the spinal cord is usually found in all of these diseases in which tetanoid contractions occur, and this, in my opinion, may be caused by the direct action of ergot, as will perhaps appear in another part of this paper. That ergot does cause contraction of the non-striated muscular tissue there can be no doubt. Dr. H. O. Hitchcock, President of this Board, says: "I venture this proposition, viz.: 'the physiological action of ergot is upon the unstriped muscular fibre wherever found, to produce tonic and contraction therein.'" ‡

Dr. Stillé says: "We have elsewhere (Vol. I., p. 782) directed attention to the grounds upon which Dr. Brown-Séquard explains the curative power of ergot in certain cases of spinal paralysis. This eminent physiologist has shown that by its power of causing contraction in the unstriped muscular fibres of the arteries it limits the afflux of blood to the parts upon which the medicine specifically acts, and in the present case diminishes the amount of blood in the spinal cord and its membranes." § This last statement may require modification, because of the thinness of the muscular walls of the blood-vessels in that part.

Dr. Hammond says:

"The action of the ergot is to lessen the diameter of the blood-vessels of the cord by its constricting power over the organic muscular fibre entering into the composition of their walls. Ten years ago I spoke as follows: 'But I have recently ascertained by actual experiment that ergot does exert the influence in question. I prepared a weak aqueous infusion of this substance, and placed it on the web of a frog's foot, under the microscope. In a few moments contraction of the capillaries ensued, and they became so small as not to allow of the passage of the blood-corpuscles. This experiment I have repeated several times, and I am perfectly satisfied that the result is as I have stated. More, I have frequently injected small quantities of the infusion into the stomach of frogs, and contraction of the capillaries of the web always followed.'" §

* Taylor's Prin. & Practice of Medical Jurisprudence, Vol. I., p. 406.

† See page 621, Vol. II., Stillé Therap. & Mat. Medica.

‡ Peninsular Med. Journal, Oct., 1874, p. 485.

§ Stillé's Therapeutics and Materia Medica, Vol. II., p. 628.

§ Diseases of the Nervous System, by Wm. A. Hammond, M. D., pp. 392-3.

Here we have direct proof of the action of ergot upon the non-striated tissue of the blood-vessels.

"In its operation upon the pregnant uterus, it produces a constant, unremitting contraction and rigidity, rather than that alternation of spasmodic effort and relaxation which is observable in the natural process of labor."*

In this city, a few years since, expulsion of an immature fœtus was caused by the use of ergot alone, there being good reason to believe that no other cause contributed to the result.

"Dr. Henschel reports a case in the *New York Medical Record* for September 1, 1874, where thirty minims of Squibb's fluid extract of ergot were given by mistake to an infant. Soon afterward there were severe abdominal pains, recurring every fifteen minutes, and lasting hardly sixty seconds. There were slight tetanic contractions of muscles of face and extremities. Diarrhœa set in four hours after administration, and continued fourteen days."†

There is also other evidence that the action of ergot is not confined to non-striated muscular tissue, but is capable of causing convulsions of the entire body. From *Cyclopedia of Practical Medicine*, 1845, Vol. IV., p. 456, I quote as follows: "When the ergot is exhibited to man in a dose of about two drachms, the symptoms usually produced by it are vertigo, headache, suffusion of face, nausea, succeeded by vomiting and purging, spasms of the stomach and intestines, and an universal feeling of debility and fatigue. If gradually introduced into the system, as occurs to those who have used for a considerable time rye meal impregnated with it, the effects are materially different, and of a two-fold description. Either a convulsive disorder is established or the disease usually known under the name of dry gangrene. The former begins with dimness of sight, giddiness, and insensibility, *symptoms which are quickly succeeded by frightful convulsions of the entire body.*‡ In this severe form the disease proves rapidly fatal; but in milder cases the convulsions occur only in paroxysms,|| and in the intervals the chief indication of disease which presents itself is an extreme voracity of appetite. This voracity either terminates in death, preceded by coma and convulsions, or in recovery after the previous appearance of anasarca, diarrhœa, *cutaneous eruptions*,§ or abscesses in different parts of the body."

A CASE OF TETANUS FOLLOWING THE USE OF ERGOT.

In the *Am. Med. Times*, May 9, 1863, a case of puerperal tetanus is reported. Just after an attack of mumps the patient had a miscarriage, being three months pregnant. She had hemorrhage, for which 10 drops of fluid ext. of ergot were given every four hours. The hemorrhage ceased, but after three days, during which it seems the ergot was continued, she felt stiffness of the jaws, followed by difficulty of swallowing, and the head was occasionally drawn back in tonic spasm. She died about three days after the attack.

FATAL POISONING BY ERGOTIZED GRAIN.

"A case of acute poisoning from ergot is recorded by Dr. Pratschke, in which uneasiness in the head, oppression of stomach, diarrhœa, urgent thirst

* U. S. Dispensatory, p. 370.

† The Cincinnati Lancet and Observer, Nov., 1874, p. 704.

‡ Italics mine.

|| May not the distinction usually made between clonic and tonic spasms be only one of difference of degree; the clonic spasm resulting from an excitation less than that which causes tonic or tetanoid muscular contraction?

burning pains in the feet, tetanic spasms, violent convulsions, and death ensued from eating freely of ergotized grain (*Lond. Med. Gaz.*, Oct., 1850, p. 579)*.

The following instance of ergot poisoning is taken from *The American Journal of Medical Sciences* of 1868, Vol. LVI., p. 577:

Poisoning from Eating Bread Containing Ergot.—"Dr. Flinzer (Von Horn's *Vjschr. f. Gess.* VIII., 1868) states that the entire family of a farmer, consisting, with his laborers, of over ten persons in all, after partaking of bread containing a large portion, say one-tenth, of ergoted rye, sickened. The symptoms were at first debility, giddiness, and loss of appetite; subsequently were added a feeling of distress, a creeping sensation in the hands and feet, tonic contractions of the extremities, profuse sweating, great thirst, and diarrhœa. A pregnant female was brought to bed five weeks before her proper time. Two of the patients died, but the fact became known too late to allow of an autopsy being made."

Speaking of ergotism, Prof. Gross says: "In this country I am not aware that it has ever been noticed in the human subject. It is said, however, to have prevailed extensively among the horned cattle of Chester county, in this State, in 1819, and in the following year in Orange county, New York, in consequence, as was supposed, of the free use of the green grass, the *poa viridis*, the seeds of which were affected with ergot."†

From "The Half-Yearly Abstract of the Medical Sciences" of 1869-70, Vol. LI., p. 100 we extract the following:

CASE OF POISONING BY ERGOT.

(By G. S. Oldbright, M. D., in *Canadian Medical Journal*, March.¹)

"In the case related by Dr. Oldbright, the ergot was given three days after delivery, to control secondary hemorrhage. The loss of flooding was very slight. About two hours or more after the administration of the ergot the patient began to feel a tingling in the fingers and feet, cramps in the legs, arms, and chest, dizziness, and weakness. The pupils became dilated, and the pulse very small, and, if memory serves, accelerated; at the same time a feeling of coldness was complained of. Stimulants and warmth were applied. In about an hour the symptoms gradually subsided, and all went on well for a few hours, when the same symptoms recurred, but with greater intensity. Stimulants were again administered. Heat was applied to the surface of the body by means of extra bed-clothes, hot bottles, and flannels dipped in hot water. This was continued for two or three hours, and it was not till the end of that time that the slightest diaphoresis, or even a good glow of heat was induced. Then the face and head suddenly became intensely congested, being of a purplish-red color. Pain was felt in the head, and the patient seemed much excited and confused. A brother practitioner was called in, and it being feared that convulsions would occur, cold cloths were applied to the head. This intense engorgement gradually subsided, but the congestion continued for two or three days, as manifested by pain in the head, photobia, etc. Another symptom which was noticed was a diarrhœa, in which the stools were of a dark gray color, looked as though meal had been stirred through them, and had a peculiarly sickly, indescribable odor. They were accompanied by

* U. S. Dispensatory, p. 270.

† Gross' System of Surgery, Vol. I., p. 209.

¹ Abstract of a paper read before the Medical Section of the Canadian Institute, Toronto, Feb. 4, 1870.

gripping pains. This condition of the bowels was noticed in another case, occurring a few months after, where ergot had been given. Here, also, there had been a good deal of weakness, and a continual recurrence of faintness, but this was attributed to loss of blood during labor and before it, the case having been almost one of placenta prævia."

"After alluding to two other cases, not so well marked as that given above, however, of which he had been informed by other medical men, Dr. Oldbright dwelt briefly upon the *modus operandi* of ergot in these cases. Wood, in his *Materia Medica and Dispensatory*, teaches that it is a direct depressant, partially paralyzing the heart and the capillaries. Dr. Oldbright did not feel prepared to go very deeply into the question, but it seemed to him probable that its primary action is excitant to the special and sympathetic portions of the nervous system, exciting muscular contraction and increased tonicity of musculo-fibrous and fibrous tissues. Hence the spasms which it causes. In this way it could diminish the calibre of the arteries and capillaries, whilst it would impede (and here we must remember how continuous and unremitting is its action on the womb), the action of the heart, keeping it in a condition of continuous partial contraction. This causes starvation of the brain (as well as of the other parts), and at once brings on the second stage,—faintness, vertigo, etc., etc. This is soon followed by the third stage of reaction and congestion of the brain."

"Amongst a number of arguments the following were adduced: It is inconsistent to attribute to the same drug the power of directly exciting muscular action in one organ, and of directly paralyzing others. Dr. Wood himself confesses, when speaking of the recommendation ergot has received in paraplegia and paralytic conditions of the bladder, that its 'applicability in these cases would scarcely be inferred from anything that is known (according to his theory) of its physiological effects.' This points to a power of inducing muscular action: so, also, do the cramps in the legs, chest, etc., which he does not explain. Again, paralysis of the capillaries would not, as Dr. Wood asserts, arrest hemorrhage. He takes it for granted that the capillaries have, *in se*, the power of propelling the blood."

ANIMALS SOMETIMES HAVE CEREBRO-SPINAL MENINGITIS.

During the epidemic at Petersburg I did not learn of any case of the disease affecting the lower animals, but in other localities it has done so. Dr. Upham of Massachusetts says: "Returns from Boston, Brighton, Charlestown, Fall River, Lynn, Newton, Stockbridge, Wakefield, and Worcester, all speak of the existence of the disease, to a greater or less extent, among animals. Horses and cows appear to have been most often affected; after that hens and chickens, and in some instances dogs and cats." * * * "Dr. O. H. Flagg, a well-informed and reliable veterinary surgeon of New Bedford, writes as follows: 'Since the first of January sixteen cases of the so-called cerebro-spinal meningitis have come under my observation and treatment. Of these, fifteen were horses, and one a calf four months old.' * Dr. Flagg gives the symptoms and *post-mortem* appearances, which are similar to those in the human body.

"Dr. Robert Law of Dublin, in reporting several sporadic cases of cerebro-spinal meningitis, observed by him in 1865, writes: 'It is a fact worthy of recording, that at the time we were attending this lady [suffering from cerebro-

* Report State Board of Health, Mass., 1874, p. 309.

spinal meningitis] nine rabbits out of eleven, which her son had, died all in the same way; their limbs seemed to fail them, they fell on their side, and then worked in convulsions, and died. Two hens fell lifeless from their roost.* Three of the rabbits were examined; in two there was congestion of the vessels of the base of the brain, and in the other vascularity of the membranes of the spinal marrow (*Dub. Jour. of Med. Sci., May, 1866*)."

"It is a noteworthy fact, that during the past eighteen months a very fatal purpuric disease has been rife among pigs in Dublin. Dr. Mapother thinks that there is much resemblance between this epizootic and human purple fever. Mr. Hugh Ferguson, the veterinary officer of the Privy Council for Ireland, states that 'purples' among pigs was very prevalent during 1846, when cerebro-spinal meningitis was epidemic at Dublin and Belfast."

ACTION OF ERGOT ON ANIMALS.

"Several experimenters have called attention to the remarkable aversion shown by *dogs* to food containing ergot. Tessier says they would rather die of hunger than eat it. Gross found it impossible to make them retain any of it except by fastening the mouth, and even then a portion of it would be vomited through the nostrils. Wright, in his numerous experiments, introduced the medicine into the stomach through a gum-elastic tube. Diez noted as its principal effects profuse salivation, vomiting, dilatation of the pupils, hurried breathing, frequent pulse, cries, trembling, staggering, paraplegia, sometimes diarrhœa, sometimes constipation, prostration, urgent thirst, convulsions, and death. Similar symptoms were observed by Wright. (*Ed. Med. and Surg. Jour., LIII., 319.*) This experimenter injected a strong infusion of ergot into the jugular veins of dogs. The symptoms were dilated pupils, a rapid pulse, convulsions, and flaccidity of the limbs followed by their tetanic rigidity, which continued after death. When a weaker infusion was employed, it caused great temporary excitement, followed by depression. A still more diluted preparation seemed to exhaust life by a progressive seductive operation. Similar results ensued when the solution was thrown into the peritoneal cavity. The more gradual action of ergot upon dogs was shown by Wright. He mixed from one to two ounces a day with the animal's food, and produced its death in the course of six or seven weeks. The succession of symptoms may be thus described. An immediate but temporary effect was shown by weakness of the hinder legs and dullness of vision, but day after day the animals grew duller, suffered from thirst, loss of appetite, and dryness of the nostrils. Then paralysis and anæsthesia of the hinder legs became more evident, the flesh wasted, acrid tears destroyed the hairs upon the face, sight and hearing failed, the heart was slow and feeble, the breath fetid, the stools and urine passed involuntarily, and death took place by exhaustion. The muscles were found, on dissection, to be pale and flabby, the heart was full of dark blood, the bronchial lining membrane and trachea were bathed in pus, the mucous membrane of the small intestine was injected. Tubercles were found in the lungs in some cases, and in some there were purulent collections in the joints."

"In Tessier's experiments, ergot was mixed with the food of *pigs*. (*Revue Med., XLIII., 140.*) They showed a reluctance to eat it. Its first effects were redness of the eyes and ears; the latter organs and the limbs then grew cold,

* Quoted from Aitkin's *Sci. and Prac. of Med.*, Vol. II, p. 456.

† Quoted from the Half-Yearly Abstract of the Med. Sciences, July to Dec., 1867, page 15, being an abstract of a paper read before Epidemiological Soc. of Dublin, by E. D. Mapother, M. D.

the joints swelled, gangrene attacked the ears, limbs, and tail, and the animals died in convulsions. One of them, six months old, lived for sixty-six days. Its intestines are described as having been inflamed and gangrenous."

"Parola (*Annales de Thérap.*, ii, 89) gave from half an ounce to two ounces daily to a *mule*. From the second day the pulse fell, the heart grew feeble, irregular, and jerking, the breathing low and deep; the appetite and flesh failed; tremulousness, a staggering gait, and dullness succeeded, * * ."

"The action of ergot upon *birds* is much more distinct and decided. Bonjean (*Traité Théorique et pratique de l'Ergot de Seigle*, Paris, 1845) gave two drachms daily of powdered ergot to *cocks* and *hens*. About the seventh day they became dull, languid, without appetite, and were effected with diarrhœa. In some cases the comb grew cold, blue, flaccid, and covered with ecchymoses; in others it was ulcerated. Black blood flowed from the nostrils, the animals were unable to walk, their breathing grew slower, and emaciation and death followed. In other cases the plumage was shed, and the beak and claws were surrounded by a bluish circle. The experiments of Tessier on *ducks* (*Revue Méd.*, XLIII., 138) furnished results almost identical with these; and in a turkey the symptoms were precisely like those just described. Gross, of Breslau (*Cantatt's Jahresbericht*, 1845, p. 255) gave ergot, or else bread that contained either it or ergotin, to *pigeons*. At first they were disposed to vomit, but in the course of two or three days showed an increased appetite. This, however, was followed by dullness, restlessness, or immobility, convulsive twitches of the muscles, diminished action of the heart and lungs, and *death between the fourth and seventh day*.*

Similar effects were produced in fowls and small birds, such as *linnets* and *sparrows*, the former of which died within forty-eight hours after eating fifteen or twenty spurs of ergot."

"Bonjean gave three drachms of the *oil* of ergot to a rabbit; it appeared distressed and feeble, and *was afterwards convulsed with opisthotonos*."*

To birds it generally proved fatal, but first produced symptoms of narcotism. Six drachm doses were not fatal to dogs, but occasioned in one case spasmodic symptoms, and in another only nausea and drowsiness. The earlier experiments of Wright with oil of ergot gave similar results to these."

"The lesions produced in animals by chronic ergotic poisoning may be thus summarily described. The venous system is engorged.† In poultry, the general color of the comb and wattles is purplish, with small blackish points, and the edges of these appendages are always quite black, and sometimes also hard and brittle. The gastro-intestinal mucous membrane is usually injected, particularly at its upper portion,† sometimes softened, and occasionally ulcerated and gangrenous. In birds, the gizzard is soft and vascular; the liver is generally enlarged and its consistence is sometimes diminished; *the meningeal vessels are usually injected, and the brain and spinal marrow, in a small proportion of cases, softened*;*† the lungs are congested, and the blood is liquid and black;† in nearly every case the muscles are rigid for some time after death; in some instances this condition is permanent, especially in the hinder legs of quadrupeds."

"The influence of ergot upon the gravid uterus in animals is not uniform. In some cases it seems to have been purely negative, in others to have destroyed the

* Italics mine.

† Compare with cerebro-spinal meningitis.

product of conception without producing its expulsion, and in still others, and these are the most numerous, to have caused abortion. Bonjean gave ergot to a female *guinea-pig* during the early stages of gestation; abortion was not occasioned, nor, indeed any symptoms whatever; so that the result of the experiment was purely negative. (*Op. cit.*, p. 78).” It may be that the lack of uniformity of action upon the uterus was due to the fact that the oil of ergot extracted with ether does not act in that manner, while that part which is left after the oil has been thus abstracted, does act upon the human uterus.* The two observers, Bonjean and Wright, who failed to get any action upon the uterus of animals, were the same who were mentioned as having experimented with the *oil* of ergot. “The experiments of Wright were to this effect; he mixed ergot with the food of a pregnant rabbit; no tendency to abortion was excited, and in due time six healthy young ones were born. The animal, still kept upon the same food, was again impregnated; she looked drowsy and moped, the fur grew erect and rough, gestation was *protracted* beyond its usual term, and three young ones were born, two of which were dead, and the third one survived but a few hours. Subsequently an abscess formed under the lower jaw, the front teeth dropped out, pus flowed from the eyes, diuresis and diarrhœa succeeded. In the twelfth week the animal died. The lungs and mesentary were tuberculous, but the intestines were sound. The same experimenter, after many trials of ergot upon pregnant bitches, concluded that it did not act as a parturifacient in them, although it sometimes appeared to injure or destroy the product of conception.”

“On the other hand, according to Diez, it produced abortion in *bitches* and in *guinea-pigs* without harm to the mother or the young, when the dose was moderate; but large doses destroyed both, and excited inflammation of the womb. In 1825, Dr. Oslere gave ergot to a *sow*, a *cow*, and a *cat*, before the completion of pregnancy, and in each case produced abortion (*Phila. Jour. of Med. and Phys. Sci.*, *XI.* 106). In 1841 an epidemic of abortion among cows occurred in the neighborhood of Trois Croix, in France, which was traced to the ergotted state of the rye and other graminæ in that district. (*Edinb. Month. Jour.*, *Jan.*, 1842, p. 73). According to Percey and Laurent, a decoction of ergot injected into the veins of a *cow* caused the animal to calve speedily.”

“The following statement of Youatt shows conclusively that ergot acts upon the uterus of animals in labor precisely as it does in the case of the human female. ‘I have for the last six or seven years been in the habit of administering the ergot of rye to quadrupeds, in cases of difficult or protracted parturition. . . . In the *monogastric*, if I may venture to use the term, I have never known it to fail of producing considerable effect, even when the uterus has been previously exhausted by continued and violent efforts. In the *ruminant*, with its compound stomach or stomachs, I have witnessed many a case of its successful exhibition. . . . The uterus has in every case responded; it has been roused to a greater or less degree of renewed action. (Pereira, *Mat. Med.*, 3d Am. Ed., ii, 137).”†

ACTION OF ERGOT ON MAN.

“*On Man.*—In 1824 Lorinser and several companions took each of them two drachms of powdered ergot upon bread and butter. The symptoms in all the

* See last paragraph on page 621, Vol. II., Stille's Therap. & Mat. Medica.

† The foregoing quoted from Stille Therap. & Mat. Med., Vol. II., pp. 610-618.

cases were alike, and consisted of some colic, nausea, and vomiting, salivation, occasionally diarrhoea, and a sense of fulness in the head. (*Edinb. Med. and Surg. Journ.*, XXVI., 453.) Similar effects were obtained by Gross and an associate who each took a drachm of ergot. (Canstatt's *Jahresbericht*, 1845, p. 256.) And such also are the symptoms ascribed to the medicine by Raige-Délorne (*Dict. de Med.*, 2eme ed., XVIII., 271). Trousseau and Maisonneuve, besides the above effects, particularly noticed dilatation of the pupils as the most constant phenomenon. It began within twelve or fourteen hours, and continued for several days. The sight was not affected. Headache and vertigo, sometimes so marked as to resemble intoxication, and followed by drowsiness, were also observed. (*Bull. de Therap.*, IV., 106.) Husa describes similar symptoms as produced by bread containing a sixth or a fifth part of ergot. The headache generally continued for several days. (*Ibid.*, LIII., 285.) Bonjean took a drachm of powdered ergot in three equal doses before breakfast, and found that the symptoms were precisely such as have been described. Other testimony to the same purpose might be adduced, but it is scarcely necessary, since the results here cited were so uniform." * * * * *

"The power of ergot to lower the *pulse* is unquestionable. In some experiments upon himself, Parola found that his pulse fell from 74 to 60, and from 79 to 72 (*Annales de Therap.*, II., 91), and Dr. Quinton Gibbon of New Jersey observed a decline of the pulse in himself from 70 to 57, and in another person from 64 to 55. In this case a repetition of the trial produced the same result. Arnal's numerous experiments showed that the action of a drachm of ergot commenced within an hour, and in the course of four hours lowered the pulse from 84 to 62. After allowing for the influence of natural causes, the time of day, rest, etc., it appeared that the pulse was still lowered, on an average, eight beats in a minute. In febrile affections, the influence of the medicine was still more marked, and sometimes the pulse fell 30 and even 36 beats in the course of five hours. The experiment upon the healthy system was four times repeated at intervals of ten days, and uniformly with the same result. (*Bull. de Therap.*, XXXVI., 534.) Bonjean found that a drachm of ergot lowered his pulse from 70 to 60. In parturient females Dr. Hardy observed that within 15 or at most 30 minutes the medicine produced a marked diminution of the pulse, which sometimes continued for several days. (*Dublin Journ. of Med. Sci.*, XXVII., 225.) Beatty estimated its reduction, under like circumstances, at 20 beats in a minute. According to Bonjean *ergotin* reduces the force but not the frequency of the pulse; but Guiland and Arnal state that it does both."

"The earliest experiments to illustrate the power of *oil* of ergot were performed by Dr. Charles Hooker of New Haven, in 1831-2. He obtained the oil by macerating ergot for several days in ether, decanting the liquid and evaporating the ether. To a medical student he gave half a drachm at two o'clock P. M., a drachm at three o'clock, and the same quantity at four o'clock. Under the second dose the pulse fell from 82 to 65, and under the third dose to 36; and the respiration from 19 to 8. Of the general symptoms, the first was a sense of tightness, followed by an unpleasant, heavy, and confused feeling in the head, and nausea like sea-sickness, general languor and lassitude, constant spitting, and vivid flashes of light before the eyes. Under the second dose there was, in addition, painful rigidity of the muscles, lassitude, lividity of the skin, dilated pupils, and a heavy countenance.* Under the

* Compare with Cerebro-Spinal Meningitis.

third dose there was, besides an increase of these symptoms, diuresis. The same phenomena were manifested in another experimenter, and in neither case did they entirely disappear for nearly a week afterwards. For three days the pulse continued under 50, the skin was still dusky, and the muscles sore. When the same oil was given in labor, no influence whatever on the uterus was displayed, but upon the child a very marked impression, as will presently be seen. Dr. Hooker then used the ergot, from which the oil employed in the above experiment had been abstracted, and found that its eebolic powers were entirely unimpaired. [*Bost. Med. and Surg. Journal* (1834), X., 298.]”

“If the phenomena here described are compared with those produced upon man by ergot in large doses, it is evident that they are identical, and that the toxic effects of this substance are due entirely to the oil which it contains.”

“Schroff, in his experiments, observed that pure ergotin in doses of from one-third of a grain to one grain produced fullness of the head, headache, and dilatation of the pupils, followed by colic and infrequency of the pulse. (*Reil's Mat. Med., d. rein. chem., Pflanzenstoffe*, p. 166.)”

“Among the effects of ergot may be noticed those which are occasioned by the use of food containing a large proportion of this substance, and which are included under the general name of *ergotism*. The records of this disease have been traced back to classical times, but they are more clearly to be recognized in the descriptions of epidemics of dry gangrene, one of which was recorded by Sigebert de Gremlour in 1096 (*Goupil, Journ. des Progres*, III., 161.) In 1597, a spasmodic disease which was attributed to ergoted rye, prevailed in Hesse and the adjacent territories. Epidemics of the same sort occurred in 1648, 1675, 1702, and 1716, in Germany, as well as in Flanders, and in France. In Sologne, a French province where rye is much cultivated, this disease has repeatedly been prevalent. Two forms of the affection have been described, the spasmodic and the gangrenous. (Ozanam, *Maladies Epidem.*, IV., 226; Bergen and Muller, Haller's *Disputations*, I., 78; Duvivier de Saint Hubert, *Traite Philosophique des Maladies Epidemiques*, etc., Paris, 1836; Heusinger, *Studien uber den Ergotismus*, Abstract in *Journ. f. Pharmakodyn.*, I., 404.)”

“*Spasmodic* ergotism begins with malaise, formication of the whole skin, cramps, and numbness of the extremities, and pains in the head and back. This state lasts from one to three weeks, and ushers in heartburn, epigastric oppression, vertigo, syncope, deafness, paroxysmal or permanent flexure of the joints, or equally violent extension and opisthotonos, twitching of the facial muscles, in some cases violent delirium, with cold skin, intense internal heat, and fetid sweats. The attacks are sometimes preceded by digestive disturbance, and last from half an hour to two hours or more. After a time the convulsions cease. They are followed by exhaustion, debility, oppression, heartburn, and a ravenous appetite, which it is dangerous to gratify. Sometimes strabismus or loss of sight succeeds (Meier of Kronstadt has shown that cata-ract is a very usual consequence of chronic ergotism,—see *Archives Gen. de Med.*, Mars., 1863, p. 350), with an eruption of bullæ upon the skin, or general insensibility. After death in fatal cases, the stomach and bowels are found inflamed, and the parenchymatous organs congested. The attack usually lasts for three or four weeks, and is very fatal. In 1735, during an epidemic in Wurtemberg, out of 500 persons attacked, 300 under 15 years of age perished.”

“The *gangrenous* form of ergotism is quite different from the foregoing.

The first symptom is a dull pain and weariness of the limbs, with a heavy and stupid expression of countenance. The skin has an earthy or jaundiced hue. The extremity or the nose about to become affected grows quite cold, and the skin over it is of a dusky red color. The gangrenous process generally begins in the central parts of the limb, and afterwards attacks the skin, extending upwards towards the trunk from the fingers and toes, causing these parts to blacken, shrivel, and harden, until they resemble the flesh of a mummy. Sometimes, however, they present the appearance of ordinary gangrene. In either case the finger, the toe, the nose, or even the extremity, separates itself from the body without hemorrhage, leaving a clean wound behind. Sometimes the flesh only is thrown off, and the bone has to be divided artificially. Cases are reported in which all four of the extremities were thus lost. Meanwhile the digestion is not always deranged, although death is sometimes preceded by diarrhoea. The attack is seldom shorter than three weeks, and in the vast majority of cases is fatal.*

TWO FORMS OF ERGOTISM.

It may be well to suggest an explanation of the manner in which ergot may act to produce sometimes spasmodic symptoms and at other times gangrene. It seems to have been proved that the oil extracted from ergot by ether, although it has active properties, does not cause well marked contraction of non-striated muscular tissue, and that what remains of ergot after the oil has been thus abstracted is capable of such action. †

The active properties of the oil may exist in a volatile acid (ergotic) and a volatile alkaloid (propylamia) extracted with the oil, as the oil itself has been stated to be a fixed oil, and "when procured by expression, this has been found to be inactive." * * "Mr. Wenzell claims to have discovered in it [ergot] two new fixed alkaloids which he proposes to name respectively ecbolina and ergotina, and in which, along with the volatile alkaloid propylamia, the virtues of the medicine reside." ‡

Just which "virtues of the medicine" reside in the fixed alkaloids he does not state, but that it is the action upon non-striated muscular tissue, is in accordance with the facts stated above, that the ergot after the oil had been abstracted was still capable of causing contraction of non-striated muscles and the poisonous properties of the oil were due to a volatile acid and alkaloid extracted with the oil. "Mr. Wright also states that the oil of ergot lowers the pulse and renders it less frequent. It may also be mentioned here that he found the vapor of this preparation [etherial extract of ergot] diffused through the air of a close room produced a tingling sensation in the limbs, distressing lassitude, irritability, and giddiness. (*Edinb. Med. & Surg. Journ.*, July, 1840, p. 51.)" §

If it be true that certain of the poisonous properties of ergot exist in great part in the volatile principles, and that to the fixed alkaloids is due the contractions of the uterus and non-striated muscles generally, it may be that we have in these facts an explanation of the two kinds of ergotism which have been observed, viz., the spasmodic and the gangrenous; and that the first named symptoms result more particularly from the volatile, while the gangrene is due to the action of that part of ergot which is left after the volatile por-

* The foregoing quotations are from Stille's Therapeutics and Materia Medica, Vol. II., pp. 610-616.

† Stille's Ther., Vol. II., pp. 612, 614, 615, and 621.

‡ U. S. Dispensatory, 12th Edition, p. 365.

§ Stille's Therap., Vol. II., p. 615.

tion has been driven off, as, for instance, it might be during the baking of bread.

More exact observation and analysis of facts are needed, however, before a conclusion can be reached on this point, and the suggestion is offered with a view of stimulating observation and experiment in this direction.

Dr. Gross says:

"The manner in which ergot acts in producing this disastrous effect has not been explained. It is very singular that its virulence should explode upon those parts of the body which are most remote from the heart, as the feet and legs, and the corresponding portions of the upper extremities, along with the nose, chin, and ears. I am myself inclined to believe that the primary impression of the poison is upon the blood, rendering it abnormally stimulant, and plastic, and the secondary upon the inner coats of the arteries, which, becoming inflamed, thereby intercepts the liquid, and thus leads to the formation of fibrinous clots. In a word, there is reason to believe that mechanical obstruction of the vessels is the direct and immediate cause of gangrene." *

In speaking of ergot and its action upon the uterus, a writer in Appleton's Cyclopaedia says: "Its action has been shown to extend to other organs possessing smooth muscular fibres." * * "It is probably by this action upon the blood-vessels that the epidemics of ergotism from the use of diseased grains as food have occurred in different parts of Europe. Ergotism assumes two forms, spasmodic and gangrenous, and probably requires for its production not only the poisonous action of ergot but the additional depressing influences of cold," † etc.

Noticing, first, that this writer refers both kinds of ergotism to the action of ergot upon non-striated muscular fibre, it may be remarked, in passing, that he has reached the same conclusion respecting the influence of cold in causing serious illness from ergotism that has been arrived at as regards cerebro-spinal meningitis, in the causation of which cold is also believed to be a factor.

There is another possible explanation of these two forms of ergotism. If we conclude that the main action of ergot, taken continuously, is that upon non-striated muscular tissue, and suppose persons exposed to this action continuously for a long time without the occurrence of anything to cause a reaction, we must conclude that, whatever other symptoms may present themselves, there will be a lessened calibre of those blood-vessels which have muscular walls, and this may go on to a complete closing of the blood-vessels in certain places, as occurred in the web of the frog's foot experimented upon by Dr. Hammond. ‡

Under such circumstances we would expect atrophy, gangrene, or death of such parts as were most poorly supplied with capillaries, and most remote from the heart; and this without supposing any other action than that known to result from the use of ergot. Continuous use of ergot, without reaction, would seem, then, to be capable of producing the gangrenous form of ergotism. The gangrene is not always of the dry kind, and this may be for the reason that there is congestion and stagnation of blood in the veins, caused by the more forcible contraction of the arteries.

Now, if in addition to the use of ergot there be some such influence as alternations of heat and cold, and through such means there be temporary increase of contraction of capillaries, followed by reaction, equally excessive, it

* Gross' System of Surgery, Vol. I., p. 203.

† Appleton's Cyclopaedia, Vol. VI., pp. 708-9.

‡ Diseases of the Nervous System, p. 393.

seems possible to conceive of the production in this manner of the "spasmodic ergotism" through disturbance of the capillary circulation in the nervous centres, especially as, though there be capillary congestion from relaxation of striated muscular tissue, the venous congestion may not be removed thereby, because of defective action of the heart, which is known to be influenced by ergot.

This line of thought leads us to consider the question :

CAN ERGOT OR A SIMILAR FUNGUS CAUSE CEREBRO-SPINAL MENINGITIS ?

If we understand this question to be : Can an inflammation of the cerebral and spinal meninges be caused by such agents ? then I think we must reserve final decision until *post-mortem* examination of a sufficient number of bodies dead from this cause shall disprove or establish the fact ; for, although a very great number of epidemics of ergotism have been recorded and described, I know of no satisfactory record of the *post-mortem* appearances of the brain and spinal cords of persons dead from ergotism. The experiments of Dr. H. Day of Stafford, England (previously quoted), did not fully establish this point as regards lower animals, although in one rabbit, that died on the eighth day and in the other two killed on the twelfth day, "more or less congestion of the membranes of the spinal cord was found on dissection." The only abnormal appearance which I observed in the membranes of the brain and spinal cord of a cat which died after eating "smut" from the mill at Petersburg, was an unusual dryness. This has been observed in some cases after death from cerebro-spinal meningitis, and has sometimes been the only abnormal appearance, and it is important to bear in mind that in order to show that the disease in question may be caused by fungi, or by one special fungus, it is not necessary to prove that the fungus always causes death through inflammation of the meninges of the brain and spinal cord, for in many deaths from this disease *post-mortem* examination has demonstrated the absence of such inflammation. But that such inflammation does occur in a certain proportion of cases of cerebro-spinal meningitis cannot be denied, and before anything can be accepted as the cause of this disease, it must be shown that it causes the same *post-mortem* results as well as similar phenomena during life.*

ERGOTISM COMPARED WITH THIS DISEASE.

In another place I have given the effects of ergot in doses insufficient to cause death, and remarked that, with a few modifications, the quotation would answer for an account of the symptoms of mild cases of cerebro-spinal meningitis. In the following account of an epidemic caused by the use of ergotized grain, one cannot fail to notice the very great similarity to the accounts we have of some epidemics of cerebro-spinal meningitis, especially as regards vertigo, disturbance of sight and hearing, formication, anæsthesia, partial gangrene, flexure of forearm or arm, convulsions, clonic and tetanic spasms, smallness of pulse, absence of well-marked fever, normal appetite, uncertain length of the disease, slow recovery, and tendency to relapse.

"In another epidemic, ascribed to the same cause [ergotism], which occurred in Upper Hesse in the year 1855-6, and was described by Dr. Heusinger, the nervous and spasmodic phenomena were predominant, with little tendency to gangrene. Out of 102 persons attacked, 12 died, and these were all under 12 years of age. Not a single individual in good circumstances was affected ; but only the miserably poor, who were compelled to live on a damaged crop, in which ergot was proved to exist. The malady generally commenced with ver-

* For *post-mortem* results in animals, see page 159 of this report.

tigo, and disturbance of sight and hearing, which were followed by formication in the fingers and toes, gradually extending over the body. Spasmodic contractions of the muscles soon appeared; the fingers were firmly flexed, and could be extended only by violence; the forearm was flexed on the arm, and the hands were pressed against the chest; and the toes were also flexed, and the ankles and knees strongly drawn inward. The muscles of the abdomen and chest, including the diaphragm, were also contracted, and the patients breathed with difficulty. The muscles of the face participated in the affection, and even those of the glottis, causing paroxysms of violent dyspnœa. The uterus, whether pregnant or not, was never attacked with spasm. The formication and the tonic *spasms were often very painful*. The pulse was small, the digestion slow, the appetite normal, and in no instance was there fever. In some cases there was a loss of sensation, generally limited to the fingers and toes, but sometimes occupying large extents of surface, or even the whole body. This anæsthesia always followed the contractions, and was sometimes itself followed by partial gangrene. The loss of sensibility extended sometimes to sight, hearing, smell, and taste. The malady was usually of a paroxysmal character, with intervals more or less prolonged. In the paroxysms there were sometimes tetanic spasms, epileptiform convulsions, loss of consciousness, and delirium of variable duration. The length of the disease was altogether uncertain; generally it continued several months; the recovery was slow; and relapses common. When death took place, it was always in a convulsive paroxysm, and by asphyxia. (*Ibid.*, IX., p. 596, Mai, 1857.) Note to second edition.”*

“The effects produced by the use of spurred rye as an article of food are very various. In some individuals the influence of the poisonous ingredient is chiefly exerted on the brain and nervous system, the most remarkable symptoms being vertigo, dimness of sight, pain, loss of sensibility, cramps and convulsions, yellow discoloration of the skin, thirst, and feeble pulse. These symptoms are greatly modified in degree in different individuals, and are sometimes slow and at other times very rapid in their progress. In the most acute form of the disease death may take place at the end of one or two days, preceded by dreadful cramps and convulsions of the whole body. Even in the milder cases, the convulsions are more or less severe towards the fatal termination of the disease; and hence this form of the disease is called *CONVULSIVE ERGOTISM* by French writers, and is vulgarly denominated in Germany *Kriebelkrankheit*, or creeping sickness. In other individuals placed apparently in similar circumstances, the most remarkable effect which follows the operation of the same septic agent is gangrene or sphacelus of certain parts of the body. Hence this form of the disease has received the name of *GANGRENOUS ERGOTISM*, *necrosis ustilaginea, seu epidemica*.” * * *

“Lang, who observed the gangrenous ergotism in Lucerne, Zurich, and Berne, says that the disease commenced with lassitude and a sensation as of insects creeping under the skin, without fever. Soon after, the extremities became cold, pale, wrinkled, and benumbed, and at last quite insensible and incapable of motion; afterwards acute pain was felt, referable to the central parts of the limbs, which was exasperated by heat and mitigated by cold applications; there was then, also, fever and headache; the pain extended from the hands and feet to the shoulders, legs, and thighs; and lastly, the affected parts became dry, shrunk, and black, and dropped off at the joints. Entire extrem-

* Wood's Therapeutics and Pharmacology, third edition, Vol. II., p. 722.

ities were thus separated from the body without hemorrhage. Many patients lost both legs, several the arms, and a few both legs and arms. (*Descriptio morborum ex usu clavorum secalinorum cum pane*, 1707.) In other cases, the chief symptoms were, at first, spasmodic contractions of the limbs, afterwards great weakness of mind, voracity, and dyspepsia, which generally terminated in fatuity or sphacelus. (*Rust's Magazine*, XXV., to which the reader is referred for a detailed account of the local and general effect of spurred rye.) The parts most frequently attacked with gangrenous ergotism are the inferior extremities. Men are more subject to the disease than women, and children and old people than adults." * * *

"All these local changes appear to be produced as direct consequences of the spurred rye, acting through the medium of the blood or nervous system, or both at the same time. For we have seen that the dead parts are separated without hemorrhage, and it is stated that the blood, when taken from a vein, is dark and so very thick that it only oozes out from the orifice of the wound." †

"The attention of the profession was first directed to the subject in a prominent manner in 1676, by Mons. Dodard, a French physician, and since then it has been frequently noticed by other writers. For a long time doubts were entertained respecting the power of ergot to produce this effect, and in order to solve these, Mons. Tessier of Paris was commissioned, many years ago, by the Royal Academy of Medicine, to investigate the matter experimentally. For this purpose he selected various animals, especially pigs, ducks, and turkeys, which he fed exclusively upon ergot; he found that most of them died between the tenth and twenty-fourth day, and that distinct marks of mortification existed in all, both externally and internally." ‡

Mr. W. T. Wenzell, of LaCrosse, Wisconsin, has investigated the properties of two alkaloids which he isolated from ergot and named "ecbolina" and "ergotina." || From "ecbolina" in the dose of one-half grain, equivalent to thirty grains of ergot, he experienced the following effects: "The functions of the brain were excited to a species of intoxication, in which participated the muscular system, causing involuntary contractions of the muscles, soon followed by nausea, loss of appetite, a sense of weight and shooting pains through the head, stiffness and soreness of the muscles of the neck and extremities, a creeping sensation along the spine." * * * * "The pulse was not materially affected until the stage of debility supervened, when the pulse fell about four beats per minute."

"Mr. W. gave a physician a solution of the chlorate of ecbolina to test its medicinal qualities in uterine hemorrhage and in parturition. * * "From the symptoms produced in the doses I had directed him to give, he was compelled to lay it aside, from the energetic and poisonous action it evinced, causing great nausea, with distressing vomiting and intense headache. He thinks the ecbolina to be a powerful agent." §

GANGRENE ACCOMPANYING CEREBRO-SPINAL MENINGITIS.

Dr. Henry Wyman of Blissfield, Mich., tells me of an epidemic of cerebro-spinal meningitis which occurred in Madison Co., Ind., in 1848. Out of twelve cases four died. In many cases the arms were flexed, as were the lower

* Compare with Cerebro-Spinal Meningitis.

† *Cyclopedia of Practical Medicine*, 1845, Vol. III., pp. 361, 362.

‡ *Gross's System of Surgery*, Vol. I., pp. 205-9.

|| *Am. Jour. Pharm.*, May, 1864.

§ Quoted from *Am. Jour. Med. Sci.*, July, 1864, pp. 275, 279.

limbs in two cases. There was coma at first, followed by rigidity of the muscles; opisthotonos on the third day; convalescence in about five days. It was a spring following a winter of unusual sickness. During the prevalence of meningitis the usual cases of remittents and intermittents were scarce. There was a case of dry gangrene within three miles of the cases of meningitis. It occurred in February. Two other cases of gangrene occurred in March. He thinks there was black rust on the wheat the previous year.

In the St. Louis Medical and Surgical Journal for May and June, 1865, Dr. T. F. Prewitt, in speaking of cases of this disease, says: "In one, a woman aged about 50, there were large livid-looking bullæ upon the feet." *

Speaking of the various eruptions attending certain cases of epidemic meningitis, Dr. Alfred Stillé says: "In some cases *gangrene* of the skin has been noticed where the spots have been peculiarly dark, and occasionally, as in typhus, from prolonged pressure." †

In a "Report of five cases of cerebro-spinal meningitis, by Henry Gray Croly, F.R.C.S.I. (Medical Press and Circular, June 5)," a case is mentioned where "black spots became larger, and before death were continuous on his arms, like gangrene." ‡

In speaking of the gangrenous form of ergotism, Prof. Gross says: "The constitutional symptoms vary, being at one time very slight, at another excessive; in general, however, the patient is tormented with fever, thirst, restlessness, and high delirium. *Under favorable circumstances* || ulcerative action is set up, and this, gradually progressing, at length eventuates in spontaneous amputation of the sphacelated structures." §

Concerning an epidemic of "Cerebro-Spinal Typhus," in Ireland, it is said (Med. Times and Gazette, May 25, 1867) that "in some cases of recovery, or in those in which life has been sufficiently prolonged for the maturation of the morbid action, or rather for nature to exhibit the process by which she struggles to eliminate the zymotic poison from the system, the livid ecchymosed spots take on a gangrenous action, thereby producing a degree of constitutional irritation, under which many of the cases succumb." ‡

In the second case of the epidemic of this disease at Petersburg—Charles Boone—the skin over the course of the sciatic nerve of the left leg was discolored, and looked as if about to take on gangrenous action. In this case it could hardly be the result of pressure, as it was not over the points of greatest pressure, but was a band of considerable width, extending down the back of the limb towards the knee joint.

DISEASES OF THE EYE IN CEREBRO-SPINAL MENINGITIS, COMPARED WITH SUCH DISEASES CAUSED BY ERGOT.

In this epidemic I was told of a little girl about three years of age, that had "sore eyes, the pupils were dilated; she was blind from some internal cause." She recovered from the disease and also recovered her sight. "Dr. Geo. Fletcher, of Lima, Ind., says that in one case which recovered, the patient lost permanently the use of one eye, there being complete amaurosis." ¶

* Am. Jour. Med. Sci., July, 1865, p. 279.

† Stillé's "Epidemic Meningitis, or Cerebro-Spinal Meningitis," p. 67.

‡ Half-yearly Abs't of the Med. Sci., July to Dec., 1867, pp. 19, 21.

|| Italics mine.

§ Gross' System of Surgery, Vol. I., p. 209.

¶ Dr. E. W. Jenks, in Buffalo Med. and Surg. Jour., Oct., 1863, quoted from Am. Jour. Med. Sci., Jan., 1864, p. 253.

Speaking of the course of cerebro-spinal meningitis, Dr. Meredith Clymer says: "Blindness may happen as an early, almost initial symptom, lasting from a few hours to several days, though Jenks reports a case of permanent loss of sight. Purulent ophthalmia, softening and ulceration of the cornea, choroiditis, hypopion, opacity of the vitreous humor, and posterior synechia may happen, or even rapid destruction of the globe."*

Stellwag says: "In some cases there is only a severe catarrhal conjunctivitis, which subsequently may be connected with ulceration of the cornea, and thus possibly destroy the eye. In other cases the ophthalmia has from the outset the character of a suppurative iridio-choroiditis, and is developed with severe inflammatory symptoms, intense redness, swelling of the conjunctiva and lids, which also quickly leads to adhesion of the papillary margin to the anterior capsule, and causes large purulent products, which are partly exuded into the anterior chamber as a hypopion, and partly infiltrate the vitreous humor, especially its anterior portion, while the greater impairment, or entire loss of vision, announces the internal participation of the retina, choroid, or optic nerve. The infiltration of the vitreous is betrayed by a very marked bright yellow reflex, which evidently proceeds from a thick opacity lying immediately upon the posterior surface of the lens, and which, from its want of vessels, may be plainly distinguished from a detached portion of retina lying upon the crystalline body. Such suppurative inflammations of the eye have been seen in meningitis in various stages of the disease, the occurrence of which is explained by the extension of the proliferate processes along the sheath of the nerves. Pathological examinations support this view."

"Sometimes an ophthalmia, in the course of a case of epidemic cerebro-spinal meningitis, has the character of a metastatic process."

"Atrophy is the ordinary result of suppurative choroiditis in epidemic cerebro-spinal meningitis, and is often evident at an early period by a marked softness of the globe. As a further consequence, suppurative perforation and phthisis of the globe have been seen."†

Dr. Moreau Morris says: Purulent ophthalmia; softening and ulceration of the cornea; choroiditis and opacity of the vitreous humor, not unfrequently are subsequent symptoms or affections."‡

PRODUCTION OF LENTICULAR CATARACT BY THE USE OF ERGOT OF RYE.

Abstract of a Paper by Dr. Ignaz Meier of Kronstadt.

"The consequences of the chronic intoxication by ergot of rye produced by the continued use of impure cereals (ergotismus convulsivus and gangrinosus) are, as is well known, nervous diseases of various kinds, contractures, anæsthesia, and alterations of the sensitive organs. The author has observed that ergotism (raphania) is also the cause of cataract. In 1857 the disease prevailed in the southeastern part of Seibenbürgen, Austria, the uncommon wetness of the summer having produced a great frequency of ergotic rye. Two hundred and eighty-three individuals were attacked in six towns, ninety-eight of whom died. The symptoms of chronic intoxication were in the beginning gastric affections, loss of appetite, nausea, diarrhœa, or constipation, and after that a creeping sensation, and a kind of torpor of the limbs; finally cramps. Permanent contractions of the feet the author saw as the conse-

* Meredith Clymer's Cerebro-Spinal Meningitis, p. 21.

† *Treatise on Diseases of the Eye*, Roosa's and Hackley's translation; New York, 2d ed., 1871. Quoted in "Cerebro-Spinal Meningitis," by Meredith Clymer, M. D.

‡ Report of Board of Health of New York City, 1871, p. 351.

quence of the latter. The pupils were generally dilated, the nails bluish, the skin yellowish or whitish, the temperature of the surface of the body low. The elimination of worms was not observed, nor the occurrence of abortion in pregnant women. The consecutive diseases were, in those more seriously affected, typhus fever, vertigo, amblyopia, or even amaurosis, impairment of hearing, difficulty of speech, insanity or idiocy, epilepsy, periodic fits of laughter, and debility.

"The inhabitants of the district live very poorly, and are much devoted to the abuse of alcohol. The majority of the patients were young. In one hundred and thirty-three cases the age was recorded, and it was found that twenty-five were from 1—10, thirty-one from 11—20, thirty-seven from 20—30, sixteen from 31—40, eleven from 41—50, nine from 51—60, four from 61—70 years. Death mostly occurred in younger individuals.*

"In the year following the epidemic the author was called on by a comparatively large number of individuals with cataracts, and came to the conclusion, after careful inquiry, that cataract was frequently consecutive to ergotism. Of twenty-three persons affected, fifteen were females and eight males; three were from 10—20, seventeen from 20—30, and three from 50—60 years. The raphania had lasted in these cases from six weeks to three months. The prevailing symptom had been cramps. In fifteen cases, a headache, lasting for months, or even a year, and combined in some cases with vertigo and noises in the head, had followed the disease, and after it had subsided, or sometimes during its existence, the gradual loss of sight in one, and soon in the second eye, had taken place. The production of cataracts was always slow, and in all cases bilateral. The consistency of the diseased lens was found to be hard two, soft twelve, and semi-fluid nine times. Complications were not present; the optic nerve and retina seemed unaffected, and the operation had mostly a good result.

"The author believes to have a right to assume that the cataracts were produced in consequence of the disturbances of nutrition of the crystalline body, caused by the chronic intoxication, or rather on the thereon dependent changes in the nervous and vascular system.

"The symptoms produced by ergotine and the oil contained in the ergot of rye are, according to Professor Schroff (*Pharmacology*, Vienna, 1856, p. 548), nausea, dryness of the throat, loss of appetite, fullness, pain and stupor in the head, dilatation of the pupils, gastralgia, and enteralgia, and diminution in frequency of the pulse. It is rendered probable, the author states, in conclusion, by observations of a less recent date, that ergotine has a peculiar influence on the system of the ciliary nerves, and influences that way the nutrition of the lens, while on the other hand, the convulsive contractions of the eye-muscles, as they were frequently observed by the patients, may have caused a change in the nutrition of the lens, like the cataracts occurring after convulsions in young children. [?]*—Am. Journal of Ophthalmology.*"†

SOURCES OF FLOUR IN CITIES AND IN RURAL DISTRICTS.

Excepting outbreaks of the disease in garrisons and at workhouses, etc., I think it will be found that a small proportion of the epidemics of cerebro-spinal meningitis has occurred in large cities. If this is true, it is a remarkable fact, and one which needs explanation. If there is any relation between this disease and the poison of smut, the following facts may bear upon this subject.

* Compare with Cases and Mortality from Cerebro-Spinal Meningitis, page 124.

† Quoted from *Am. Jour. Med. Sci.*, p. 540, Apr., 1864.

There is one great distinction between the source of the flour used in large cities and that used in many rural districts. Cities are supplied, in great part at least, with flour made at large mills called "merchant mills," while in rural districts much of the flour used is made at smaller mills, from wheat raised in the vicinity. In visiting mills, during my investigations, my attention has been called to the fact that there is a very great difference between the elaborate machinery employed for cleaning the wheat in "merchant mills" and the antiquated and imperfect arrangements for this purpose in many of the "custom mills." And while some of this latter class of mills are provided with ordinary smut machines, others have nothing of the kind worthy of mention.

It is not safe to rest on the assumption that because there are now elaborate and complete machines for cleaning wheat, all mills are supplied with such. This assumption is not in accordance with the facts. I was told that very near the locality where cerebro-spinal meningitis prevailed at Manchester, in this State, there is a mill that has no suitable apparatus for separating the smut from the wheat.

SMUT IN BUCKWHEAT USED FOR FOOD.

Some facts, which seemed to me of importance, were communicated to me by Mr. Wm. Swindells, the miller at Petersburg, where the epidemic of cerebro-spinal meningitis occurred. He said that buckwheat was more frequently than other grains affected with smut, and that it was not the custom at his mill, and I understood him to say that it was not at other mills, to run buckwheat through the smut machine before grinding it. The greatest number of epidemics have occurred during the winter and spring months; and that corresponds to the season of the year when buckwheat is most freely used. I did not succeed in finding out much about the proportion of persons at Petersburg who used this article of food and afterwards had the disease in question; but I was told that the buckwheat contained more than the usual quantity of smut, and, as before stated, it was not run through the smut machine before being ground.

Mr. Swindells also told me that it was not the custom for millers to take any measures for removing smut from corn. But, as a rule, no considerable amount of smutty corn is ground for human food.

In this connection it seems worth while to bear in mind the POSSIBILITY OF THE DISEASE BEING COMMUNICATED BY MEANS OF MILK. It is not improbable that the milk of cows fed upon grain or grass affected with smut may contain some of the poisonous material derived therefrom, especially such principles as tend to go with the oily portion, and which, from the experiments of Dr. Hooker and Mr. Wright,* appear to be, to some extent, volatile. "He found the vapor of this preparation, diffused through the air of a close room, produced a tingling sensation of the limbs, distressing lassitude, irritability, and giddiness."*

If milch cows eat grain or hay affected with smut, or drink it in water, it seems quite probable that the milk will contain at least a portion of the poisonous principle, as it is a well-known fact that milk is quite generally flavored by substances used as food. Act No. 26, Laws of Mich., 1873, very properly forbids the sale of milk from cows fed on refuse from distilleries

*Stille's Therap. Vol. II., p. 615.

or breweries; doubtless for the very good reason that such milk has been proved to be injurious to persons using it.*

QUANTITY OF SMUT SEPARATED FROM WHEAT.

Perhaps this is as good relation as any in which to place another class of facts ascertained during my investigations in connection with this epidemic. I was informed that the quantity of smut and other refuse material separated from grain by the smut machines amounted to several tons at each flouring mill. There is a flouring mill at each of the two villages where this epidemic was most fatal,—Petersburg and Dundee.

The river Raisin, along which this epidemic occurred, has a large number of flouring mills on its banks. The method of dealing with smut is not quite the same in all of these mills. In many of them the smut is conveyed by a shaft into the river. In others it is simply blown out into the air. At Manchester it is thus disposed of, being discharged on that side of the mill toward the river. The mill is on the west side of the river, and just below the dam. During the summer and autumn of 1873, cerebro-spinal meningitis broke out on the east side of the river, not far below the mill. The prevailing wind in this locality is, I believe, generally from the west and southwest. There may be no relation of cause and effect between these facts; certainly no such relation is proved; but since smut is known to be a violent poison, I have thought it well to report these facts. In one of the largest mills in Jackson,—on Grand River,—the smut is collected in a tight room, and a large part of it removed to the country by a farmer who, it seems, makes some use of it. In ordinary seasons this "smut" consists largely of the little hair-like material from the small end of the wheat kernels; but in certain seasons a considerable proportion is really what is known as smut, and consists of spores of fungi.

WHAT IS ERGOT?

In Dr. H. C. Woods' late Treatise on Materia Medica and Toxicology, I find, on page 458, a concise statement, as follows:

"Among the lowest of vegetable organisms, and distinguished from all other plants by the absence of chlorophyll, are the fungi. There are in most cases two distinct states or stages in the life of a fungus: in the first of these, the vegetative period, it exists as a *mycelium*, a usually filamentous mass or flocculus, whose sole function is to grow and increase; in the second stage the *thallus*, or ordinary fungus or mushroom, is formed; to it is assigned the function of developing reproductive bodies, after whose formation it perishes. Between these stages there is in some fungi an intermediate one, in which the plant exists as a *sclerotium*. The genus *Claviceps* comprises a number of parasitic fungi, which develop in the pistils of the various species of Graminæ. The official ergot is the sclerotium of the *Claviceps* (*C. purpurea* Tulasne) which infests the grain of the *Secale cereale*, or common rye. The first appearance of the fungus is during the earliest life of the pistil, at the base of which there arises a minute flocculent mass of mycelial filaments. These filaments, continually growing and invading all parts of the tissue of the pistil, at last form of it an irregular whitish body, at the base of which, after a time, appears a dark-colored body, the sclerotium, which continues to grow, lifting up the diseased and withering mass formed out of the original pistil, and finally developing into a perfect ergot.

* See Pages 31 to 66, Trans. Med. Soc. of N. Y. Communication of N. Y. Academy of Med., being Report of Com. on City Milk, by S. R. Percy, M. D.

"If a fresh, living ergot be placed in a damp, warm place, after a time little cracks will appear in its surface, and out through these cracks little round bodies will project, and finally be raised up on stalks, and constitute perfect thalli,—minute fungi, which finally produce spores."

This is very different from the various fungi known as "smut," this name conveying an idea of the fine, dusty blackness of the spores which in the smut known as *Tilletia caries* are produced in immense numbers in the germen of the grain itself without the production of a distinct thallus.

Taylor, in his *Principles of Medical Jurisprudence*, Vol. II., p. 184, says:

"The ergot in ordinary use is that of rye; but the ergot of wheat is said to be equally effectual, and the same perhaps may be stated of the ergot of all grasses."

Dr. Stillé says:

"Ergot is produced by other cereals besides rye. Mialhe found that the ergot of wheat is identical with that of rye in the qualities of its proximate principles and in its action upon the gravid uterus (*Bull. de Thérap.*, XXXIX., 41). His conclusions have been confirmed by Pourcher (*Ibid.*, XLVIII., 467), and by Jobert (*Am. Journ. of Med. Sci.*, Oct., 1856, p. 479.)" *

Dr. H. C. Wood says:

"It is not always the rye which causes these frightful losses of life, as Heusinger (*Journal für Pharmakodynamik*, Bd. I., p. 405) has traced one epidemic to diseased oats." †

Referring to ergot, it is stated in the U. S. Dispensatory, twelfth edition, page 365, that "It is probable that this morbid growth has similar properties from whatever plant derived; and the fact has been proved in relation to the ergot of wheat. (See *Am. Jour. Med. Sci.*, N. S., XXXII., 479.)‡ Indeed, in a case reported by Dr. D. L. McGugin (*Iowa Med. Jour.*, IV., 93),‡ this variety of ergot is said to have succeeded promptly when that of rye, previously tried, had failed." In a footnote to this last sentence it is stated that the ergot of wheat has been recommended because less liable to change, and that there is reason to believe that this is true, "for Prof. Bentley of London found that of two specimens, one of the ergot of rye, the other of wheat, which had been kept under similar circumstances for ten years, the former was quite destroyed, while the latter was apparently unchanged. Ergot is rarer in wheat than in rye; and in the head of the former there is generally but one and very rarely more than two of the diseased grains. It is produced usually in wheat in wet seasons, and on that side of the head most exposed to dampness. It is shorter and much thicker than the ergot of rye, being about half an inch long and three-quarters of an inch or more in circumference, and cleft into two or three divisions. In color and smell it resembles the spurred rye. (*Pharm. Jour.*, March and April, 1863, pp. 423 and 442.)" †

On page 485, Chapman's *Therapeutics*, Vol. I., 1825, I find the following relative to the production of ergot. "The Abbe Fontana planted a number of single grains of rye, and upon the top of each placed several grains of ergot. The result was a crop of this substance, showing something similar to infection."

WHAT IS THE "SMUT" WHICH AFFECTS DIFFERENT KINDS OF GRAIN.

In this part of the world very many different kinds of fungi are commonly designated simply as "smut." We hear of "smut wheat," "smut corn,"

* *Therapeutics and Materia Medica*, Vol. II., p. 607.

† *Materia Medica and Toxicology*, p. 469.

‡ I regret that I have not been able to see the original papers referred to above.

"smut buckwheat," and occasionally of "smut grass." Although these are known to mycologists as belonging to different species and genera, they have certain general characters in common; they are "parasitic on living plants," and most of them, as also the "brands" and "rusts," belong to the order Cæomacei.*

One of these well known to farmers is the "smut" which is found in wheat after it is threshed, the kernels affected being not very different from the perfect wheat in external appearance, but which are filled with myriads of black spores. In England this seems to be commonly known as "bunt," and in works on fungi, as *Tilletia caries*, the first name indicating the genus and the last the species. As before mentioned, it belongs to the order Cæomacei, which is included in the family Coniomycetes, while ergot of rye—*Claviceps purpurea*, belongs to the order Sphæriacei, and family Ascomycetes. According to Berkeley, one of the best authorities on such subjects, "This family [Coniomycetes] is distinguished by the vast predominance of the reproductive bodies over the rest of the plant, if not in size, at least in abundance, and from the ease with which, in general, they fall from the point of attachment, in consequence of which, as the name implies, they have a dusty appearance, and often soil the fingers of those who handle them."†

Unfortunately this character admirably fits the members of this family to maintain their existence. Rev. M. J. Berkeley of England has experimented with the spores of *Tilletia caries*, and ascertained that their germination proceeds through the development of four successive generations. In Cooke's Introduction to the Study of Microscopic Fungi, this process is briefly described as follows: "When these are made to germinate, a kind of stem is protruded, upon which small clusters of elongated thread-like spores of the second generation, or sporidia, are produced. After a time the spores conjugate, or become united by short transverse processes in the same manner as has been observed in some of the lower forms of algæ. The conjugated spores in the next stage germinate and produce a third kind of fruit, different from either of the preceding, and constituting a third generation. These in turn germinate and produce a fourth order of re-productive organs, so that in the process of growth the 'bunt' spores evidently pass through four generations. Hence, as one result, the number of germinating bodies is greatly increased, as well as their power of inflicting injury in a corresponding diminution of size. There are still many points in the history of the growth and development through successive generations of the 'bunt' spores, but enough is known, on the one hand, to show that this is a true vegetative parasite, and not merely a diseased condition of the tissues of the wheat plant, and on the other, that it is perfectly distinct from all the phases of the other and similar parasitic fungi which affect the wheat crop."‡

There is a growing belief that "like causes produce like effects," and it is a fact worthy of attention that so many diseases which are in many respects similar, have been attributed to fungi which are also different from, but have many things in common with each other. A few years since the Texas cattle disease was quite thoroughly studied by the Board of Health of the city of New York, and, although the cause was not certainly proved, yet there was some reason to believe that it might be a fungus taken in with the food of the animals. Great numbers of "micrococci" were uniformly found present in the blood and bile of the diseased animals, and it was claimed that these

* Hand-Book of British Fungi, Vol. II., p. 511.

† Hand-Book of British Fungi, Cooke, Vol. I., p. 414.

‡ Rust, Smut, Mildew, and Mould, Cooke, pp. 88, 89.

micrococci could be and were artificially developed into a mature fungus. This fungus is figured and described in the report of the New York Board of Health for 1868, which also contains a very complete account of the disease. (Drs. Billings and Curtis, of Washington, D. C., have tested the development of the micrococci, and did not verify the statement.*) The symptoms of the disease as well as the *post-mortem* results were similar in many respects to the disease being studied in this report. It began with a chill or cold stage, after which the temperature was increased; there was delirium, the neck was not thrown back, but the head was retracted or straitened on the neck, there was retraction of the abdomen,—“tucking up of the belly,”—constipation, difficulty in urinating, and, frequently, bloody urine; after death numerous ecchymoses were found in different parts of the body, and occasionally extravasations of blood; there was enlarged spleen.† “In three instances the condition of the brain was carefully examined, because it was presumed that those particular cases might be found to have suffered from acute meningitis or from cerebral congestion. No trace of actual inflammation was found, but there was evidence of congestion of the cerebral vessels in two of the cases. The medulla oblongata was examined in these cases, and sufficient effusion was found in one instance to have produced morbid, nervous, and muscular phenomena. Yet the observations finally led to the conclusion that all, or nearly all the delirious actions, distorted movements and postures, and comatose conditions that characterized various cases, were attributed to the toxæmia which constitutes the essential quality of the disease.”‡ We see here a conclusion similar to that by most writers as regards cerebro-spinal meningitis, namely, that many of the symptoms referable to the cerebro-spinal system are not due to an inflammation therein, but to blood-poisoning. It seems to me that a more rational explanation would be to let the actual *post-mortem* results, such as congestion of the veins and sinuses of the brain and spinal cord, ecchymoses and extravasations of blood, account for much of the nervous disturbance, and then let the excessive muscular contraction, which is also evident, account for the forcing of blood into the veins in such situations, as also into the spleen, which is found softened as well as enlarged.

As pointed out in another part of this report, the known action of some of these fungi is to cause muscular contraction, particularly of the involuntary muscles, and it would not be inconsistent with this knowledge if it should turn out that the Texas cattle disease was due to a fungus taken into the bodies of the animals.

In 1862, J. H. Salisbury, M. D., of Newark, Ohio, communicated to the American Journal of the Medical Sciences, a paper on fungi, with an account of experiments showing the influence of the fungi of wheat straw on the human system. He inoculated several persons with spores obtained from wheat straw allowed to ferment by means of heat and moisture. “From the inoculations as far as they have gone, in from twenty-four to seventy-two hours, the effects begin to show themselves in lassitude, chilliness, catarrhal symptoms, and pains through the forehead and temples.”||

The symptoms which he describes are: Chills, followed by fever, pain in the head and back, nausea, fullness and throbbing in the head, deafness, sneezing, sensitiveness sometimes amounting to inflammation of the eyes,

* Report U. S. Com'r of Agriculture on Diseases of Cattle, 1869-70, pp. 156-170.

† Enlarged spleen has been mentioned as one of the *post-mortem* evidences in cerebro-spinal meningitis.

‡ Report B'd of Health of N. Y. City, 1868, p. 284.

|| Am. Jour. Med. Sci., July, 1862, p. 27.

burning congestive feeling in the scalp, oppression in the chest, dryness and soreness of the throat, hoarseness, coughing, redness in spots under the skin, and an eruption somewhat similar to that of measles, these manifestations disappearing after about eight days.

In this same article the following statement appears :

“At the monthly meeting of the ‘Farmers’ Club,’ near Newark, Ohio, last month, several of the farmers stated to Mr. Dille that it was quite common, after threshing wheat, for persons who had been exposed much to the dust, to be taken with severe chills, followed by a high fever, catarrhal symptoms, and an eruption on the face. None of them could state that any one had ever had the attack twice; nor whether they had known any cases to follow the threshing of any other kind of grain than wheat.

“It is well known among swine growers that when they bed their hogs in straw they are affected with an eruption in the throat, fauces and roof of mouth, accompanied with coughing.”*

The fungi figured and described by Dr. Salisbury as found on straw allowed to “heat” or ferment, although somewhat similar, were different from any others which have been mentioned in this report.

On page 241 of his work on Food and Dietetics, Dr. Pavy says:

“Bread also becomes the seat of development of certain species of fungi—(*Penicillium oidium*, etc.)—in other words, becomes mouldy on keeping, and the more quickly so in proportion as it contains water. The same likewise happens with wheat and flour under the presence of moisture. The existence of this low form of vegetable growth renders the articles pervaded dangerous for use. They are liable to produce injurious and even fatal consequences. Dr. Christison states that on the continent repeated instances have occurred of severe and even dangerous poisoning by spoiled or mouldy rye bread, barley bread, and wheat bread; and that several instances have been observed of horses having been killed in a short space of time with symptoms of irritant poisoning by eating such bread with their ordinary food. It has further been noticed that the consumption of mouldy oats has been followed by fatal consequences. Dr. Parkes [*Pract. Hygien*, 3d Ed., p. 223], quoting from Professor Varnell, states that ‘six horses died in three days from eating mouldy oats; there was a large amount of matted mycelium, and this, when given to other horses for experiment, killed them in thirty-six hours.’”

EFFORTS TO TRACE THE CAUSE OF SOME PREVIOUS EPIDEMICS.

Cerebro-spinal meningitis prevailed at the State Reform School near Lansing in 1863 and again in the winter of 1865–6. I have been unable to learn much concerning the conditions existing at that time. There seems to have been some complaint in regard to the insufficiency of the clothing of the boys, and of the coldness of the dormitories where they slept. It has not yet been proved that cold or the reaction therefrom is sufficient of itself to cause the disease, but the fact that a large proportion of the epidemics occur in the winter and spring would seem to indicate this as one of the factors, and there is other evidence tending to the same conclusion. An effort was made to ascertain the source of the breadstuffs used at the Reform School at that time. Application was made to the Superintendent for this information, but after the lapse of a considerable time his reply was that he had been unable to learn that fact. There is, however, indirect evidence bearing upon the subject, so far as

* *Am. Jour. Med. Sci.*, July, 1862, p. 22.

relates to the winter of 1865-6. It is stated by numerous authorities that ergot of rye is more prevalent in wet than in dry seasons, and this seems to be true of many of those species of fungi which attack the different kinds of grain. Now the character of the season in Michigan during the time when the cereals used for food in the winter of 1865-6 were ripening and being harvested was unusually wet, and in addition to the inference that the fungi which attack wheat would be likely to be present, we find a statement of the presence of some of them.

"This year [1865], over a large portion of the State, *particularly the central and western*,* the summer and early autumn were so wet as to seriously injure some farm products." * * "Through the summer of 1865 rain fell at short intervals, and with the constantly damp atmosphere which prevailed, even the surface of the ground was scarcely dried." * *

"According to the returns received by the Commissioner of Agriculture, Washington, D. C., the deficiency in the yield of wheat in the country for 1865, as compared with 1864, is 12,172,994 bushels. It will be observed that this relates only to the *quantity* of the crop. Its quality is inferior throughout the Western States." * * In this State, "*rust, also, made its appearance on many fields*,"* induced, probably, by the prevalence of wet weather, alternating with warm sunshine. Add to these casualties the injury from rains after the crop was cut, and the depreciation in the *quality* of the grain must be obvious, though not easily stated in figures."†

The winter of 1865-6 is said to have been "a dry and rather cold winter."‡

As regards the prevalence of the disease at the Reform School during the winter of 1865-6, it appears to be, at least, possible that it may be accounted for by the facts just stated, and which may be summarized as follows: Throughout that part of the State from which its food supply was probably derived, the grain raised in 1865 was of poor quality because of the fungi which attacked it during the wet and warm summer months; the winter of 1865-6 was dry and cold; the inmates were not warmly clothed, and their dormitories were unusually cold.

It is much to be regretted that the conditions of the crops and seasons preceding and during the outbreak of 1863 were not recorded in some State publication, but at that time the State Board of Agriculture was only just organized, and had not begun that work.

It has been remarked that the fungi which destroy wheat and other grains are most destructive during wet seasons, but it will not answer to conclude that they are present in every wet season, for heat is also required for their most active growth. In examining with reference to wetness of season during ripening of grain, it will be seen that the summer of 1866 was unusually wet, and the question may arise, why did not cerebro-spinal meningitis prevail in the winter of 1866-7, if the fungi of cereals are factors in its causation. By referring to the statement of crops in this State in 1866, it is found that although the wheat crop was below the average yield, and was to some extent damaged by heating and sprouting in the stack, still, where not injured in this manner, it *was of "good quality,"* and there was no mention of rust or smut, the season being wet, but cool.

Epidemic cerebro-spinal meningitis prevailed in Philadelphia and vicinity

* Italics mine.

† Report of Secretary of the State Board of Agriculture of Michigan, for the year 1865, pp. 7, 8, 9, 10.

‡ Report of Secretary of the State Board of Agriculture of Michigan, 1863, p. 63.

during the winter of 1863, and spring of 1864. The meteorological conditions observed at Philadelphia in spring and summer of 1863, were as follows: "The amount of rain that fell during the spring and summer [of 1863] was 28.542 inches, being 8.210 more than 1862, while the number of days it rained amounted to 82, which exceeded the number in 1862 by 20 days. The seasons, therefore, have been uncommonly wet."* From meteorological observations by Prof. J. H. Kirkpatrick of the Philadelphia High School, published in same journal as above, I learn that for the month of June, 1863, the maximum temperature was 91.5 deg., the mean temperature was 69.48 deg., the average dew point was 54.43 deg. This evidence is not very valuable as it is, but may lead to the bringing forth of some more conclusive one way or the other. It is not probable that the city was supplied to any great extent by food derived from cereals raised near the city, and yet the comparatively few persons in the city who contracted this disease may have used the same food as did those in the various villages near by, and which may have been raised in that vicinity; or the milk used may have been from cows fed on hay made and cured in that vicinity during that warm and wet summer of 1863. The question which I wish to present, and ask evidence concerning, is this: Does cerebro-spinal meningitis usually appear during or following an unusually cold winter following an unusually warm and wet summer during which fungi were caused to pervade the cereals and grasses afterwards directly or indirectly used for human food?

An epidemic which occurred at Elmira, New York, in 1857, has been mentioned in this report. An effort to learn the condition of the wheat raised in 1856 proved unsuccessful. W. A. Armstrong, Secretary of the Elmira Farmers' Club, writes as follows: "I am sorry to say no precise information is attainable. I have accurate knowledge of my own crop for that year, but I was not then a resident of this county. I have inquired of old farmers here about the characteristics of that season's crop, but there are only vague impressions regarding its character; these, however, seem to indicate an unusual amount of smut."

So far as I can learn from the Vital Statistics of Michigan, the deaths from cerebro-spinal meningitis in this State appear as follows: During the year 1868, 7 deaths; 1869, 5 deaths; 1870, 9 deaths; 1871, 18 deaths; 1872, 248, including those returned as from "meningitis," etc. For the year 1873 the returns are not yet all in, and for 1874 the deaths are not yet collected by the supervisors, but judging from the best evidence at hand it seems probable that in 1873 there were more deaths from this cause in this State than in any previous year, and more than in 1874.

By careful examination of the Reports of the State Board of Agriculture, I find that it is not the uniform custom of the correspondents in different parts of the State to record the diseases which affect the crops, or the peculiarities of the seasons, although these subjects are occasionally mentioned. So far as relates to the wheat crop for the year 1870, the following is about the only positive record of its quality being affected: "The wheat crop was more than an average yield, but, owing to the wet season, was somewhat damaged." †

In some parts of the State it was reported as of good quality.

For the year 1871, so far as shown by reports printed in the Report of the State Board of Agriculture, the wheat crop was of excellent quality.

* Am. Jour. Med. Sci., July, 1864, p. 96.

† Report Sec'y Ingham Co. Agr'l Soc., in Report of Sec'y of State B'd of Agriculture for the year 1870.

For the year 1872, there is very little said in the Report, the following being about all of consequence, and showing that it was of good quality in some localities and not good in others.

"A few showers before harvest time, 1872, just when the plant was in its most susceptible condition to be most affected, caused rust. In consequence, the crop was almost a failure; the quantity being light, and quality but second rate." *

"The spring [1872] opened very late, the summer was very hot, and after the first of June, very dry."

"The wheat crop was considerably more than an average in quantity, and the quality was excellent." †

But in the same Report I find a record of extraordinary meteorological conditions during the winter of 1872-3, which may bear upon the subject of the unusual prevalence of cerebro-spinal meningitis in this State, in December, 1872, and spring of 1873.

"The month of December [1872] was more than 8 deg. below the average temperature of that month, ‡ a fitting forerunner of the terribly cold winter of 1873. The period from December 22d to 25th will long be remembered as the severest 'cold spell' ever witnessed in our State. On the morning of the 24th of December the thermometer stood at 32 deg. below zero. This extreme cold was not confined to our State, but appears to have swept as a polar-wave from Pembina in a southeasterly direction across Minnesota, Wisconsin, and Michigan, thence easterly across Ontario and New York, and thence northeasterly to Quebec. The damage to fruit trees and the suffering which it caused to all classes will not soon be forgotten." ||

Now although it is so difficult to obtain any reliable information regarding the diseases of the cereals within late years, it happens that I have been able to learn of a very remarkable blight of the wheat crop in Europe in 1804,—the year preceding a well-recognized outbreak of epidemic cerebro-spinal meningitis in Europe. On page 13 of his work on the subject of this disease, Dr. Stillé says: "The first account of epidemic meningitis within the period we have referred to was published in 1805, by Vieusseux, who at once declared that neither he nor any of his colleagues had ever seen a similar disease." Although that outbreak began in Europe in 1805, it did not begin in this country until the following year, at Medfield, Massachusetts. Of the quality of the cereals in this country at that time I have found no mention, but, in Loudon's *Encyclopædia of Plants*, published in London, 1836, page 1048, one may read that "the alarming state of the harvest of August, 1804, from what is vulgarly called blight, induced Sir Joseph Banks to have some blighted stalks of wheat examined under a powerful microscope, and drawings made from them by Mr. Francis Bauer. These were published in a pamphlet in January, 1805." The figures of the fungi in the *Encyclopædia* are copied from this work of Sir Joseph Banks. Whether or not the disease prevailed in the immediate vicinity where the affected wheat was raised I have not been able to learn. Dr. Meredith Clymer says: "In Prussia, Holland, Rhenish

* Twenty-third Annual Report of the Board of Management of the Genesee County Agr'l Society, in "Report of Sec'y of Mich. State Board of Agriculture" for the year 1872, p. 135.

† O. H. P. Sheldon, Secretary of Van Buren County Agr'l Society, in Report Sec'y State B'd of Ag., 1872, p. 162.

‡ Prof. Kedzie has kept a thorough meteorological record at the College since 1864.

|| Prof. R. C. Kedzie, in Report of Sec'y Mich. State Board of Agriculture for the year 1872, p. 290.

Germany, Bavaria, and Eastern France, there were occasional outbreaks of the disease from 1805 to 1815.”*

SOME POST-MORTEM APPEARANCES WHICH NEED EXPLANATION.

Without attempting to deny that in some cases of this disease evidences of inflammation of the meninges of the brain and spinal cord are found, it nevertheless seems true that in a large proportion of the records of *post-mortem* examinations no satisfactory evidence of this appears. Thus, in a case reported to the College of Physicians of Philadelphia by Dr. Jewell in 1864, and which appears to have been a well-marked case of this disease, the patient died after an illness of 48 hours. Omitting references to other organs: “On cutting through the scalp the blood flowed away more freely than usual, and it was found that it was abnormally fluid within the veins. The vessels of the dura mater were remarkably congested with fluid blood, very dark in color. A yellow effusion existed in the subarachnoid space; it proved to be of a serous character, and to exist in the spinal canal also.”†

Dr. Levick reported the case of a child that died on the first day of the disease where “On removing the calvaria a large ecchymosis was found under the pericranium near the sagittal suture. The vessels of the dura mater were filled with dark fluid blood, which could readily be pushed aside by the handle of the scalpel. The substance of the brain and of the medulla oblongata was natural in its appearance and consistence. There was no effusion in the ventricle, and the most careful examination failed to detect the slightest evidence of inflammatory exudation.”‡

In the American Journal of the Medical Sciences for October, 1865, page 509, is an abstract of Prof. Menderlich’s observations on the epidemic in Germany in 1864–5, wherein the following remarks occur: “It is particularly worthy of remark that although many phenomena of this affection are explicable by the lesions found in and about the nervous centres, yet many others are present which cannot be referred to those lesions, which indeed are not themselves uniformly proportioned in extent to the gravity of the symptoms. Hence we must be convinced that cerebro-spinal meningitis is rather a constitutional than a local disease, and one whose symptoms are not to be explained merely by a reference to its anatomical lesions alone.” * * “It is precisely the severest cases which hurry on without remission to a fatal close, and in which the slightest anatomical alterations are discovered, or, indeed, cannot be detected at all.” * * “Cases occur in which it seems as if the life of the body in all its parts perished by a sudden and deadly intoxication.”

On page 278 of the same journal for July, 1865, is an account of an autopsy of a woman who died twelve hours after she had gone to bed apparently in her usual health. It is reported by James J. Levick, M. D., one of the physicians of Pennsylvania Hospital, as a case of “spotted fever without cerebro-spinal meningitis.” “On cutting through the scalp there was an escape of dark fluid blood with which the vessels were turgid. A large ecchymosis was found on the left temporal bone, and smaller ones on other parts of the cranium. The meningeal vessels were filled with black blood. The most careful examination failed to detect any evidence of inflammation either in the substance of the brain or in its membranes. The spinal cord was removed in its entire length,

* Cerebro-Spinal Meningitis, p. 6.

† Am. Jour. Med. Sci., July, 1864, pp. 130, 131.

‡ Am. Jour. Med. Sci., July, 1864, p. 136.

and was examined both by the unassisted eye and with the microscope. It was of firm consistence, and in every way free from disease."

In Dr. Moreau Morris' article in the report of the Board of Health of New York city for the year 1871, page 359, is an account of the *post-mortem* appearances in a case that died eighteen hours after first attack. "The serous and mucous coats of the stomach showed purpuric spots similar to those on the body. It was also scattered, though less abundantly, over the peritoneal coat of both large and small intestines. Lungs, heart, liver, and kidneys were healthy. The blood was very fluid. The whole of the surface of the brain was intensely congested, the veins and sinuses being gorged with very fluid blood, though not entirely devoid of coagula. On section of the brain little points of blood netted out everywhere. The ventricles were nearly dry. Consistence of brain natural; no exudations or purulent matter found."

It is to be regretted that the microscopical appearances of the blood-vessels of the brain and spinal cord have not been generally recorded. If any such records have been kept I have failed to find them. But from such records as those just preceding, one would expect to find some such condition of the smaller blood-vessels as described by Dr. Dickenson in tetanus, and quoted in another part of this report. Prominent facts to be accounted for are the ecchymoses, or extravasations of blood which seem to take place in various parts of the body, and the engorgement of the veins and sinuses of the brain with black blood. In the most severe cases, where death takes place most rapidly, these have been the most apparent causes of death. It is difficult to see how blood can get outside of the vessels as it does in this disease except one of two things is true. Either there must be some unusual rottenness of the walls of the vessels, or they must be subjected to unusual strain. And this even though the blood be rather more than usually fluid, for passive hemorrhages are not common in this disease. It seems reasonable to conclude that the ecchymotic spots and the venous engorgement of the brain are both due to unusual blood-pressure in the vessels, and that this is due to general muscular spasm, or tonic contraction.

CERTAIN FACTS IN ANATOMY WHICH MAY BEAR UPON THE CAUSE OF THIS DISEASE.

"The diameter of the capillaries varies in different tissues of the body, their usual size being about one three-thousandths part of an inch. The smallest are those of the brain, and the mucous membrane of the intestines; the largest those of the skin and the marrow of the bones." *

This seems to have a bearing upon the view that in cerebro-spinal meningitis there is primarily a starved condition of the cerebral tissue, through excessive contraction amounting to almost entire obliteration of the minute blood-vessels. Such contraction has elsewhere been suggested as the cause of the dry gangrene in one form of ergotism. The smallest capillaries being those of the brain and mucous membrane of the intestines, we might expect that the contraction of blood-vessels would be most serious in its effects upon those tissues; more particularly in the brain for the reason that it would suffer not only from small supply of blood, but also from impoverished blood, because of the impoverished intestinal circulation interfering with digestion. It will not answer, however, to assume without further proof that the tension of the walls of the blood-vessels is the same in all parts of the body. There

* Gray's Anatomy, p. 360.

are other points to be considered before coming to a conclusion as to the relative quantity supplied to the brain under such circumstances, for the tendency or power of contraction may be much greater in some parts than in others, in which case extraordinary distention might result where the contraction of the walls was least.

The fact that the largest capillaries are those of the skin, may have some connection with the appearance of spots and ecchymoses in this disease. The extent of tissue supplied by each capillary may also bear upon the subject of death of parts. "In the liver and lung the interspaces are smaller than the capillary vessels themselves. In the kidney, in the conjunctiva, and in the cutis, the interspaces are from three to four times as large as the capillaries which form them." *

Such contraction of muscular walls of blood-vessels as is believed to result from the action of ergot and of cold would impede the general circulation, and would tend to force the blood into situations where the vessels were least supplied with muscular walls.

"Some arteries have extremely thin coats in proportion to their size; this is especially the case in those situated in the cavity of the cranium and spinal canal, the difference depending upon the greater thinness of the external and middle coats." * * "Some arteries, as those in the cranium, are not included in sheaths." * * Arteries are also provided with nerves; they are derived chiefly from the sympathetic, but partly from the cerebro-spinal system. * * "According to Kölliker, the majority of the arteries of the brain and spinal cord, those of the choroid, of the placenta, as well as many arteries of muscles, glands, and membranes, are unprovided with them." †

We have been examining the structure of arteries and capillaries; congestion of veins in certain parts would result from contraction of muscular walls of blood-vessels.

"Muscular tissue is wanting in the veins: 1. Of the maternal parts of the placenta. 2. *In most of the cerebral veins, and sinuses of the dura mater.* 3. *In the veins of the retina.*‡ 4. In the veins of the cancellous tissue of bones. 5. In the venous spaces of the corpora cavernosa. The veins of the above-mentioned parts have an internal epithelial lining, supported on one or more layers of areolar tissue."

"Most veins are provided with valves, which serve to prevent the reflux of the blood." * * "The cerebral and spinal veins, the veins of the cancellated tissue of bone, the pulmonary veins, and the umbilical vein and its branches, are also destitute of valves." ||

ATTEMPT TO ACCOUNT FOR THE EXUDATION SOMETIMES FOUND.

If we accept the evidence which seems conclusive of the contraction of non-striated muscles through certain influences, such as cold, ergot, and similar fungi, and bear in mind the pressure which under the action of such agents, would be exerted upon the walls of blood-vessels not well supplied with muscular tissue and not protected by valves, we may have some conception of the possibility of the effusion of serum, the exudation of fibrin, and the extravasation of blood in such situations, which, it will be seen by the quotations from Gray's Anatomy, are, more particularly, the brain and spinal cord. This

* Gray's Anatomy, p. 361.

† Gray's Anatomy, p. 360-1.

‡ Italics mine.

|| Gray's Anatomy, p. 457.

must not be assumed as proof that in this disease the exudation upon the cerebro-spinal membranes is actually caused in this manner. It is offered as a possible explanation, which must be verified or disproved by future investigation. In the same spirit we may offer an EXPLANATION OF THE SOFTENING OF THE BRAIN AND SPINAL CORD which is usually found in patients dead from cerebro-spinal meningitis. Stillé says: "The *substance of the brain* is generally softened." He mentions the observations of numerous writers to establish this point. "*Softening of the spinal marrow* appears to be less frequent than that of the brain."* Nevertheless he mentions several cases, and says: "Partial and superficial softening of the cervical portion we have seen repeatedly."* Speaking of cerebral softening, Dr. Hammond says: "Most authors treat of it in direct connection with obliteration of the cerebral arteries, but, although frequently due to this cause, it may be produced by others."† Now if the general contraction of all blood-vessels well supplied with muscular walls does not result in a great contraction of the vessels within the brain and spinal cord, and in that manner, deprive the brain of its nutriment, there seems to be good reason for believing that there would be congestion not only of the thin-coated arteries of the brain and spinal canal, but also of "most of the cerebral veins" in which Gray says "muscular tissue is wanting." Such a condition of arterial and venous congestion would not be favorable to repair of nervous tissue, and conjoined with a sluggish circulation, would go far toward explaining the softening and disintegration of the brain and spinal cord, especially as the blood would be impoverished because of the difficulty of getting nutriment into it through vessels in such tonic contraction.

Some recent experiments on rabbits seem to show that in them ergot causes contraction of the vessels of the brain, as well as of other blood vessels. "Dr. Max Schuler—*Berl. Klin. Wochenschrift, Chicago Jour. Nervous Diseases*, Oct. 2, 1874, records some experiments," which, although not conclusive as to the action of the substances named upon man are worthy of attention. "He found that *after the continued application of large sinapisms the cerebral vascularity was reduced.*" "Dr. Schuler, experimenting with nitrite of amyl, as with mustard, was able to demonstrate the hitherto supposed action of this drug, viz.: that it *relaxed the cerebral vessels.*" "Dr. Schuler demonstrated that injection of ergotine was followed by a powerful and continued vascular contraction at the place of injection, and in both the arteries and veins of the pia mater." He found that "ergotine would contract the cerebral vessels when they were dilated to their fullest extent. On the contrary, nitrite of amyl would not dilate vessels contracted by ergotine." "He found that ergotine would contract arterioles when the sympathetic nerve supplying those arterioles was divided. Thus we have direct proof that ergotine acts on the muscular fibre of the arteriole."‡

It may be remarked that, although ergot may cause contraction of the blood-vessels of the brain, as also of all other blood-vessels having muscular walls, including the heart, the contraction of those vessels having the least muscular fibre must yield to the stronger contraction of those having the greatest amount of muscular fibre, and as elsewhere pointed out, the muscular walls of the arteries of the brain and spinal cord are thin, and the veins in those parts have no valves.

* Stillé on Epidemic Meningitis, p. 89.

† Diseases of the Nervous System, p. 137.

‡ Detroit Review of Medicine, February, 1875, p. 108.

A careful study of the account of the experiments referred to above shows that the immediate effects of these agents was different from the effects of their continued influence. Immediately, and for a short time after the influence of the mustard began, there was an alternation of contraction and dilation, resulting at last in a permanent contraction, under the full influence of the substance. In another part of this report, while endeavoring to account for the two different sets of symptoms caused by ergoted grain, I suggested that perhaps the so-called spasmodic ergotism resulted from alternate contraction and dilation of the blood-vessels through the influence of food containing the fungus, modified by varying conditions of heat and cold, position of the body in sleep, etc. It will be remembered that the symptoms of spasmodic ergotism are similar in many respect to those of cerebro-spinal meningitis. In connection with the experiments mentioned above, I recall the suggestion just referred to for the purpose of studying the subject a little more closely since the statement of certain facts which have been made to follow that part of the paper in which the suggestion occurred. It may now be studied in connection with the question: CAN SOME SYMPTOMS OF MENINGITIS BE EXPLAINED THROUGH ALTERNATE CONTRACTION AND DILATION OF BLOOD VESSELS?

The probable result of such changes may perhaps be better stated in the form of propositions, as follows:

1. The brain and spinal cord are normally surrounded by a fluid.
2. The cranium and spinal canal are rigid, and their contents are of nearly uniform bulk.
3. When the blood-vessels of the brain and spinal cord are greatly contracted, the extra space thus left within the cranium and spinal canal is probably filled by an extra quantity of fluid.
4. Under such conditions, if the blood-vessels are suddenly dilated, there will be pressure upon the brain and spinal cord.

Some of the prominent symptoms of this disease would be accounted for through compression of the spinal cord and brain. In another part of this paper, while speaking of cold and changes in temperature, it was remarked that some of the prominent symptoms of this disease would be accounted for by irritation of the pneumogastric and spinal accessory nerves near their origin within the spinal canal. If the foregoing propositions are correct, we should have the conditions for mechanical irritation through pressure upon the nervous substance wherever there was sudden dilation following extreme contraction of the blood-vessels of any considerable portion of the brain and spinal cord; and it seems reasonable to conclude that the pressure would be most severe in its effects at the points of dilation. Other things equal, this dilation would be great where there was least normal stimulation of vaso-motor nerves, and greatest where there was entire suspension of function of such nerves, through division or complete reaction from previous over-excitation. Prof. Flint says that "the local circulations are regulated in accordance with impressions made on sensory nerves,"* etc. I have elsewhere called attention to the fact that, under ordinary circumstances, cold is not allowed to strike the body except in the air passages. During the inspiration of cold air the blood which goes to the lungs must lose heat rapidly. We have seen that cold is one of the most important agents in causing contraction of muscular tissue. Can there be any doubt that it has a powerful influence upon the nerves distributed

* Physiology, p. 439.

to the lungs and heart? If it has, then such sudden changes as that from breathing the cold external air of winter to breathing that of a warm room should cause a corresponding change in the "local circulation" of that part of the brain and spinal cord from whence those nerves are derived. Under ordinary circumstances this causes, at the most, only some giddiness; but through the excessive influence of ergot, or a fungus having similar properties of powerfully influencing the contraction of blood-vessels, it may be possible for the added influence of cold to produce extraordinary contraction, and this to be followed by an equally extraordinary dilation of the blood-vessels, because of almost complete paralysis of the nerves so exposed when they are again brought under the relaxing influence of heat. The nerves of the face and air passages would be most exposed to cold, and, therefore, to reaction therefrom. There may be some relation of cause and effect between these facts,* and the symptoms of giddiness, nausea and vomiting, dilation of pupils, tetanoid contractions of muscles of the neck, etc., so frequently found in cerebro-spinal meningitis.

There is reason to believe that cases of cerebro-spinal meningitis and tetanus are sometimes confounded. There are cases of meningitis on record which if there had chanced to have been a previous wound might, consistently, have been reported as tetanus. The question arises whether tetanus is not a similar form of disease which is usually caused in great part by physical pain. Let us study the action of pain. Under the influence of severe pain there is usually a marked contraction of voluntary muscles. There is what is called a "straining of every nerve." The whole muscular system is in a state of unusual tension. In health, the circulation in the veins is largely carried on by the alternations of pressure and relaxation which the muscles exert upon them during ordinary healthful conditions, the valves in the veins preventing the blood from flowing from the heart. Given a state of continuous unusual muscular tension, such as sometimes results from wounds, there would be a corresponding tension in those blood-vessels least compressed by muscles. Those in the cranium and spinal canal are the ones, as previously remarked. Fortunately facts have been recorded which bear directly upon this subject. The microscopical appearances of the spinal cord in tetanus are described by Dr. Dickenson: "The blood-vessels appear to be, if not the first, at least an early seat of change. Distended with blood, not only to their uttermost natural capacity, but dilated to many times their proper width, and crammed with blood corpuscles so as to look like solid cylinders, their condition gave evidence of an altogether abnormal relation between the pressure of the blood and the resistance of the walls. Either blood had been propelled into them with supernatural force, or what is more likely [?], the tension of their coats had been lessened by a change in their innervation. The overcharge of the vessels led to the escape of their contents. In some cases blood corpuscles were extruded. More often only the fluid portion of the blood traversed the wall, to appear as the translucent structureless material which played so prominent a part in the destruction of the cord." * * "At the same time a certain amount of disintegration of the nervous elements had taken place, where the exudation came into contact with them, such as might result if, as suggested by Mr. Lockhart Clarke, the exudation had a solvent action upon the tissue. It is probable that the tendency to disintegration in the nervous matter may have been enhanced by the unnatural state of the blood-vessels, and the consequent imperfect nutrition of the cord." †

* Another point to be borne in mind is the vaso-motor centre, supposed to be in the medulla oblongata.
 † *Am. Jour. Med. Sci.*, April, 1869, p. 469.

An attempt to study and explain the cause of tetanus was not the primary object of this report. But it has been found necessary to study this and other allied affections in order to appreciate the evidence as to the cause of cerebro-spinal meningitis. Prof. Gross says: "The term tetanus is a generic one, employed to denote a peculiar affection of the nerves, characterized by violent contraction of the voluntary muscles, with irregular intervals of partial, though seldom of complete, relaxation."*

The several species of tetanus are: *trismus*, or locked jaw; *opisthotonos*, when the body is bent backward; *emprosthotos*, when it is bent forward; *pleurothotonos*, when it is drawn to one side; *trismus nascentium*, or infantile tetanus, a few days after birth. Trismus and opisthotonos are frequently prominent phenomena in cerebro-spinal meningitis, and there is no reason to believe that these species of tetanus are then caused in a very different manner than when they follow a wound. Not a very large proportion of all wounds are followed by tetanus; something more than an ordinary wound is therefore needed. Prof. Gross says: "The fact is, in persons of a nervous, irritable temperament, any injury, however trifling or insignificant in itself, may readily induce the disease, especially in hot and damp states of the atmosphere, or during sudden transitions from heat to cold. Exposure to cold draughts, by which the body is suddenly chilled, is, under such circumstances, extremely liable to provoke an attack. The effect of cold air, when permitted to play directly upon the body, is well illustrated by an occurrence that took place after the battle of Ticonderoga in 1758. The wounded were exposed the whole night after the action, in open boats, upon Lake George, and the consequence was that nine of them died of locked jaw."†

The combined influence of cold, pain, fear, or unusual nervous susceptibility, is probably sufficient to cause such muscular tension as to force the blood into the feebly resisting blood-vessels of the brain and spinal cord, and to produce the condition described by Dr. Dickenson quoted above. When we remember the "extremely thin coats" of the arteries of the brain and spinal cord, it seems evident that the direct action of any agent, such as ergot, that undoubtedly produces marked contraction of the blood-vessels, would be toward the production of just such a condition of the brain and spinal cord as is described above, as found in tetanus. To deny this seems to me like denying that "motion occurs in the direction of least resistance." It seems reasonable to conclude that the use of ergot in food or medicine would tend toward the production of tetanus. Seeking the cause of tetanus is also seeking the cause of part of the phenomena of cerebro-spinal meningitis. But in this last mentioned disease there are additional phenomena which it has been thought were best explained by the influence of some "blood-poison." It should be borne in mind, however, that while in tetanus caused by a wound in connection with cold, the spinal congestion is caused in great part by the extraordinary toniccy of the voluntary muscles combined with the unusual contraction of the vessels of the surface of the body, in the spinal congestion which I suppose to be, under certain circumstances, caused by ergot and substances having similar action upon involuntary muscular fibre, we may have the same influence of cold combined with it; but, whether it is or not, there is probably a general contraction of all blood-vessels having muscular coats, and this results in deranging digestion, assimilation, and especially interferes with the removal of

* Gross' Surgery, Vol. I, p. 771.

† Gross' Surgery, Vol. I, p. 772.

effete matter from the system. In cerebro-spinal meningitis there is frequently suppression of the urine. The bowels are sometimes constipated.

If the foregoing is a true view of tetanus and the action of ergot, we have in ergot of rye, wheat, and perhaps other fungi, something capable of acting toward the production of tetanus, and, in addition, of so interfering with digestion and excretion as to produce a depraved condition of the blood sufficient to account for the leading symptoms, if not for all the symptoms of cerebro-spinal meningitis. If these views are correct, the reason is plain why cold alone, a wound alone, or both together, do not cause all the phenomena of epidemic meningitis, for the production of which something is required which shall add the influence of those poisonous matters which in health are rapidly excreted from the body. They may enable us to see why when the disease occurs without the influence of cold some of the symptoms have been mistaken for typhus,—a disease due to animal poison in the system. They explain the reason why this disease is more frequent in cold weather, when the contraction of the blood-vessels of the surface is great through the influence of cold alone. They explain how the tension which occurs in fear, which is recognized as a factor in the causation of the disease, is capable of producing such an effect. They may throw some light upon other affections, as, for instance, tetanus, hydrophobia, cholera, intermittent fever, puerperal convulsions, and hysteria.

In order to prove that a disease is caused by a given substance or substances, agency or agencies, it is necessary to prove that the alleged cause is capable of producing the phenomena manifested by the disease, that it is present and acting whenever such disease occurs, and in order to fix upon one thing or agency alone, it must appear that no other known agency or substance capable of producing such phenomena is present and acting.

With more labor than will probably be realized by most persons who read the results, I have endeavored to collect all the evidence which was readily accessible to me relative to a number of substances and agencies, and to group it in such manner as that it should bear upon one of the three essential points just mentioned, and have its proper value in sustaining or breaking down the idea that each particular substance or agent was a cause of this disease. The results of several such groupings do not appear in this report, being considered of minor importance. That so much prominence is given to the subjects of cold and certain fungi, is because they seemed to be "true causes;" and, as regards the latter, a large amount of evidence has been given for the reason that it was believed that even then it would not by many be accepted as a prominent cause of the disease.

In some cases an effort has been made to show that it is not impossible that certain agencies and substances may cause the disease in question, and to offer a rational explanation of a possible method. This has been done partly for the purpose of removing obstacles to a complete and thorough collection of the evidence on the subject; for so long as people could "not understand how an excessive amount of ozone could possibly cause any such disease;" or "see no possible connection between cold and this disease," and conclude that "of course it is impossible that the disease could have been caused by that article of food,"*—while we are so frequently met with such views as these, it is exceedingly difficult to collect any reliable evidence upon the subject.

More evidence seems desirable as to whether food containing ergot, or a

* Referring to flour made from smut wheat, "Providence Journal," R. I., Aug. 27th, 1874.

fungus having similar properties, has been used in communities where the disease has prevailed as an epidemic, and whether the particular persons who have had the disease ate of such food. Reference has been made to an unsuccessful effort to learn the conditions existing and the source and nature of the food supply at the Reform School in this State at the time the disease prevailed there in 1863-5. A communication was also addressed to the U. S. Minister at Paris, France, asking if it were possible to learn the nature of the crops in localities from which the French army were supplied in those years when it suffered so severely from this terrible disease. The reply of the secretary of the legation was as follows: "The French government has at length replied to my request for the information you wanted about smut in wheat. They regret that the long lapse of time since the dates referred to, prevents both the Minister of War, and the Minister of Agriculture, to whom application was made, from being able to answer your questions." But unless more attention is paid to such subjects in France than in the United States the lapse of time was a matter of no consequence, and no better result would have been reached if the inquiry had related to the year last past. The general prevalence of the disease throughout the United States during the year 1872 prompted a letter of inquiry to the Hon. Frederick Watts, Commissioner of Agriculture. The essential part of his reply was as follows: "The reports made to this Department do not mention smut in wheat in such detail as to enable us to state, with any approach to accuracy, the proportion of wheat so affected in any locality—nor even whether there was more or less of smut than usual in wheat, or other grain, in 1871." Until this time there seems to have been no demand for any such information. I made extraordinary efforts to obtain it for the reason that if it could be obtained in connection with past epidemics we need not go groping after this knowledge through numerous epidemics in the future. When the next epidemic comes it is to be hoped that the agriculturists will contribute to its study more definite knowledge respecting the disease, or absence of disease, affecting the principal crops which furnish us with food. But if they do not, it is possible that the chemists may give us the information sought. In the U. S. Dispensatory, on page 369 of the twelfth edition, is the following:

TEST FOR ERGOT IN FLOUR.

"The odor of ergot is no doubt owing to the liberation of its volatile alkaloid, probably in consequence of a slow decomposition of the native salt. A method of detecting ergot in a mixed powder, rye flour, for example, is thus afforded. If, on the addition of solution of potassa, the odor of ergot is perceived, its presence is sufficiently proved."

Since investigating the subject, I have had no opportunity of applying this test to flour known to have been actually used for food by a person suffering from this disease. Such a test applied to two samples of flour obtained from the Petersburg mill at the time of my visit, yielded negative or at least unsatisfactory results, as did also a similar test of two other suspected samples.

Microscopical examination of the flour has been suggested, and it may be possible that the mature spores of *Tilletia Caries*, the "bunt" of the English, and the kind of "smut" of this country which is found in wheat after it is threshed, may be found in flour made from such wheat, but I have never found any. It does not seem probable, however, that ergot of rye can be readily detected microscopically, for it contains nothing which is so very peculiar and

striking as to be easily identified in that manner, and if there is a real "ergot of wheat" it is probable that the same remark will apply to that.

In order to prove that this disease is caused mainly by any particular poison, it would be necessary to show that no other known poison capable of producing the disease is present and acting.

There are very many poisons which produce symptoms similar to those of cerebro-spinal meningitis, even to some of the *post-mortem* appearances; but in the results of most of these poisons there are certain points which distinguish the particular poison. Thus, in poisoning by strychnine there is trismus and opisthotonos, but there is also more violent tetanic action of most of the muscles of the body; there is no headache, nor, as a rule, vomiting; the *post-mortem* appearances include spinal congestion, but do not include evidences of inflammation, at least not in cases of rapid poisoning with large doses. In any search for a special poison capable of being the main cause of this disease, many such poisons can be thrown out as not present and acting. This is true of strychnia, of such fungi as might be mistaken for the edible mushrooms, and because of the prevalence of the disease in cold weather, of all poisons affecting green foods, except possibly such poisonous roots as may be mistaken for edible roots and preserved in cellars. There is one exception of the class last mentioned, but it is not one that appears to be capable of accounting for epidemics of this disease: In Taylor's *Prin. and Prac. of Med. Juris.* it is stated that persons have been poisoned by taking the roots of Monkshood (*Aconitum Napellus*) for those of horse-radish, these having been dug after the leaves had fallen. Horse-radish is frequently used at the season of the year when this disease prevails, but although the symptoms of poisoning by aconite are in some respects similar to those of the disease in question, there is no probability of its being the cause, for in this country the plant is not a very common one, and cases of the disease often occur in many different families at about the same time, and whatever external poison, if any, be found to cause the disease, it must evidently be one which, although having its distribution somewhat limited to certain localities, is so common to all classes of people in each locality as to have eluded observation up to this time. Cases of poisoning by mushrooms, by poisonous roots, by shell-fish, and even by cheese, are, probably, as a rule, detected, for the reason that not all the members of a family use such articles of food. The very fact that the cause of cerebro-spinal meningitis has not been discovered, is good evidence that it is not connected with any of the *secondary* articles of food. If connected with the food, the probabilities are greatly in favor of its being found in connection with the flour, for no other article of food is usually so distributed as to account for the distribution of the disease. Of all the poisons likely to be present in the flour, the one which is known to produce symptoms most like those of this disease is the fungus known as ergot. Other fungi are known to be poisonous, and are frequently found in articles of food prepared from the cereals.

Among the various poisons which are capable of producing symptoms somewhat similar to those of this disease is one which has been found in the food. On page 397, Vol. I., Taylor's *Prin. and Practice of Medical Jurisprudence*, the author says: "In January, 1854, Dr. Kingsley of Roscrea furnished me with the particulars of some cases in which several families, including about thirty persons, suffered severely from the effects of bread containing, by accidental admixture, the flour of darnel seeds." The symptoms exhibited, as described by Dr. Kingsley, were of a form of intoxication. There was giddi-

ness, tremblings of the arms and legs, impaired vision, coldness of the hands and feet, great prostration, and in some cases vomiting, burning heat in mouth and throat, confusion in head, and small and irregular pulse. There is no mention of lock-jaw or other tetanoid symptoms, as in cerebro-spinal meningitis, and the patients were convalescent on the following day, whereas in the disease in question convalescence is usually protracted. It is possible, however, that in small and long-continued doses the flour of the seeds of the bearded darnel may be capable of producing a form of poisoning similar to or even identical with cerebro-spinal meningitis. Inasmuch as it is certainly a dangerous poison, the characters of the plant should be well known to farmers in order that it may not, through ignorance of its dangerous qualities, be allowed to increase and eventually cause wide-spread poisoning by its admixture with the flour which enters into the constitution of so many of the ordinary articles of food. The botanical name of the bearded darnel is *Lolium Temulentum*. In Gray's Manual of Botany it is located in "Grain-fields, Massachusetts, and Penn: rare,—Grain noxious; almost the only such instance among grasses." It is an annual plant, "adventive from Europe." In a note the author remarks that "I here rank with the *adventive* plants those which De Candolle terms plants cultivated without or against man's will."* As it has come across the ocean it seems probable that, unless effort is made to prevent it, it may spread still more easily throughout our own country.

There is one article which is now almost as widely distributed, and that is the potato. It will be referred to again in another place. Some of the phenomena of this disease might be accounted for if it could be shown that arsenic was so distributed as to be taken into the system, by persons throughout whole communities. I know of no evidence that the paris green, used to destroy potato-bugs, enters into the potatoes, or that it has ever been found in drinking-water from wells in the vicinity of its use; and this disease occurred long before its use for that purpose. Arsenical pigments have been in use for a long period of time, however, and are very largely distributed in dwellings, more especially on wall-papers and window-shades, but the effects of arsenic in that form are known, and do not correspond very closely with this disease, wherein the attack is quite frequently sudden.

Phosphorus is a very violent poison, even in minute doses, and its effects are sufficiently similar to the phenomena of this disease to demand thorough examination. In combination with other elements, it is found in many, if not in most, articles of food. If it shall appear that it is ever taken into the system in any such combination as will liberate it in a poisonous form, it will be worthy of serious attention. It is a component of nervous tissue, and, in health, it is excreted in considerable quantity, especially in the urine. It may be worthy of consideration in this connection that in cerebro-spinal meningitis there is frequently, if not generally, a scanty flow of urine, and it is possible that some of the secondary phenomena of the disease are due to the retention in the system of some of the combinations of phosphorus.

In a late medical periodical received while the first part of this report is passing through the press, I find a paragraph which bears upon this subject, and quote it with the remark that the statement needs confirmation:

"Professor Levi of the University of Pisa has just made known, as the result of numerous analytical and experimental researches, that the physiolog-

ical, therapeutical, and obstetric properties of ergot of rye are due to the presence of phosphoric acid, which it contains in abundance, much more than to its organic principles (like ergotin, ecbalin, etc.), to which until now had been exclusively ascribed all the various actions of the substance." *

Those who have read this report thus far will have seen that the view which seems most reasonable to the writer of this report is that the disease in question is a tetanoid fever tending to cerebro-spinal meningitis if sufficiently prolonged; that it is caused by substances and agencies which cause excessive general muscular contraction, and which thereby produce excessive pressure throughout the blood-vessels of the body, causing, among other derangements, those blood-vessels to yield which are least well-supplied with strong muscular walls. This conclusion having reference more to a mechanism than to any particular poison or substance, it is not essential to exclude any substance or agent as a possible cause, but it is desirable to have evidence as to the possibility of producing such pathological conditions through such methods. After the greater part of this report and the conclusions at the close of it were written, and some part of it printed, the writer has fortunately been able to examine, somewhat hastily, the late work of Dr. H. C. Wood, of Philadelphia, on Therapeutics, and has inserted in different parts of this reports a few quotations. It seems that many observers have concluded that ergot must cause a rise of arterial pressure, and many experiments have confirmed this view. Dr. Wood says: "Seemingly the most elaborate and thorough examination yet made as to the action of ergot upon the blood-vessels, as evinced by its influence on arterial pressure, is that of P. Eberty (*Inaug. Dissert.*, Halle, 1873)." * * *

"He finds that the arterial pressure rises directly and enormously after the injection of ergotin. This rise, which he acknowledges to be chiefly due to the contraction of the vessels, occurs in the veins as well as in the arteries, and in the frog as well as in the dog and the rabbit." * * "Until farther studies are made, no positive opinion can be arrived at as to whether ergotic vaso-motor spasm is peripheral or centric, but the probabilities seem to be very strong in favor of the latter origin." * * "The rise of arterial pressure produced by ergot, and the existence of vaso-motor spasm, must, I think, be considered as proven facts; yet Handelin is stated to have found that the arterial pressure falls after the exhibition of the poison. Brown-Séquard has insisted (*Archives de Physiologie*, 1870, t. III., p. 434) that in ergotic poisoning there are two periods: first, vaso-motor spasm; second, vaso-motor paralysis. It is very possible that he is correct, and that Handelin's results were simply due to his having used such enormous doses of ergot as at once to overpower the vaso-motor apparatus." †

The argument from successful treatment is one difficult to apply to this subject, for the reason that no treatment has been attended with much success. The same is true of tetanus. The following, from Dr. H. C. Wood's late work on Therapeutics, may serve as a starting-point, if the view proposed in this report as to the mechanism of the production of cerebro-spinal meningitis and of tetanus is deemed worthy of examination. On page 302, speaking of nitrite of amyl, Dr. Wood says: "Its physiological action would indicate that it should be of service in all cases of spasm of the capillaries, of the bronchial tubes, and of the muscular system generally." On the page following, for quite other reasons, however, he suggests its use in tetanus, and says: "It has

* Medical and Surgical Reporter, Phila. Feb. 20, 1873, p. 153.

† Materia Medica and Toxicology, p. 463-4.

been used, so far as I know, in only two cases (London *Lancet*, 1871), both of which recovered, one with the amyl salt alone, and the other with it and chloral."

It may be added that in cerebro-spinal meningitis hot baths and hot applications to the surface have been frequently recommended as useful, especially in the beginning of the disease.

It was hardly to have been expected that in this first attempt it would be possible for the writer to demonstrate the cause of this disease which has been the subject of more or less study for a century. If he has succeeded in contributing in any degree to the advancement of our knowledge of its cause, or in clearing the ground and laying out work which shall advance it, the labor will be well repaid.

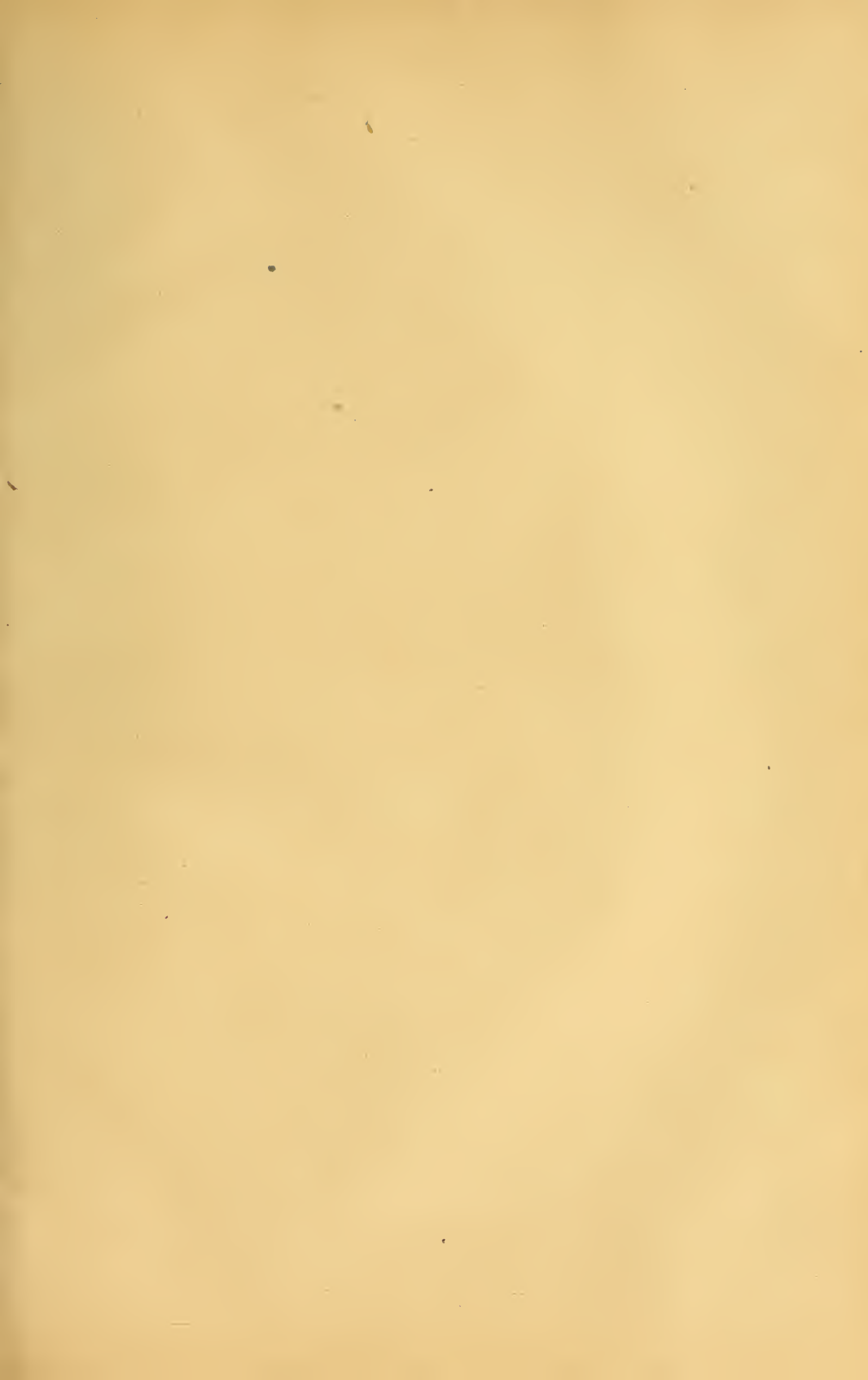
What are some of the questions believed to have been now or previously answered, and what are those to which answers are still wanted? It is probable that this would elicit a different reply from different persons. Answering only for myself, I conclude that: 1. There does not seem to be sufficient evidence to prove that the disease is contagious, in the ordinary sense of the term. 2. I am not satisfied that it has a general atmospheric cause. 3. It does not seem probable that epidemics of this disease are caused by over-crowding, imperfect ventilation, bad drainage or sewerage, or by any of the ordinary unsanitary conditions acting alone, although the death-rate may undoubtedly be increased thereby when the disease occurs under such conditions. 4. Observations are much needed to show what relation, if any, exists between the presence of ozone in the atmosphere and the prevalence of this disease, as also between extreme dryness of the atmosphere and this disease. 5. The exact constitution of the drinking water should be ascertained; and any evidence going to show that it is materially changed in winter or spring might bear upon the study of the cause of this disease. 6. An important question remains to be studied as to what relation, if any, exists between this disease and those plants which yield solanine, more particularly the common potato. An epidemic of a disease manifesting many symptoms common to the one in question, was attributed to poisonous exhalations from a mass of decomposing potatoes collected at a starch factory. Cases of poisoning by sprouted potatoes are on record. This disease frequently occurs in spring, at which season potatoes have frequently undergone one or the other of these changes referred to above. 7. Another subject which deserves study in connection with this disease, is the possibility of the introduction into or the retention in the system of an injurious amount of phosphorus or some of its combinations, as that substance is poisonous in exceedingly small quantities, and some of the phenomena attendant thereon are suggestive of this disease. Possibly this may be accounted for by the fact of the retention of urine, and of other excretions, in this disease, and therefore of the phosphates which in health are rapidly excreted. 8. It is not probable that epidemic cerebro-spinal meningitis is entirely due to a single cause; and as a rule at the present time it is only wide-spread when several causes acting in the same general direction are equally wide-spread and combine to render it epidemic. 9. To specify the prominent causes, I conclude that, as regards season of year, which has been known to have some close relation to this disease, it is probable that cold and reaction therefrom are the principal controlling elements, and that cold is one of the causes of this disease. As regards ergot, smut, and all fungi which cause great contraction of non-striated muscles, they are probably capable of being prominent causes of this disease, and further evidence is

very desirable as to the precise changes which they induce in the human body and which appear *post-mortem*, in order to enable us to determine the above proposition, as also whether epidemics of this disease usually owe their violence in great degree to the presence of such substances in the food. 10. Fear is doubtless capable of contributing to its causation; as is also, physical pain, mental anxiety, and, perhaps, undue mental labor. 11. The recumbent position of the body, as in sleep (and perhaps the condition of sleep), favors the production of the disease, so far as relates to general congestion of the brain and spinal cord, for the reason that whereas in the upright position the force of gravity favors the return of venous blood from the brain and spinal cord, in lying down the force of gravity does not act to prevent excessive pressure upon the blood vessels throughout the body from forcing the blood into the veins of the brain and spinal cord, which are not provided with valves; and, the muscular coats of the cerebro-spinal arteries being thin, there is then a tendency toward their undue distension.

To summarize and state in general terms the conclusions reached,—it is extremely probable, but not yet proved, that any substance or agency which causes unusual contraction of the non-striated muscular tissue throughout the body is capable of being a prominent cause, and any substance, agent, bodily position, condition, sensation, or emotion, which tends to produce general muscular tension, or otherwise to force unduly the blood into the blood-vessels of the brain and spinal cord, is capable of contributing to the production of this disease.

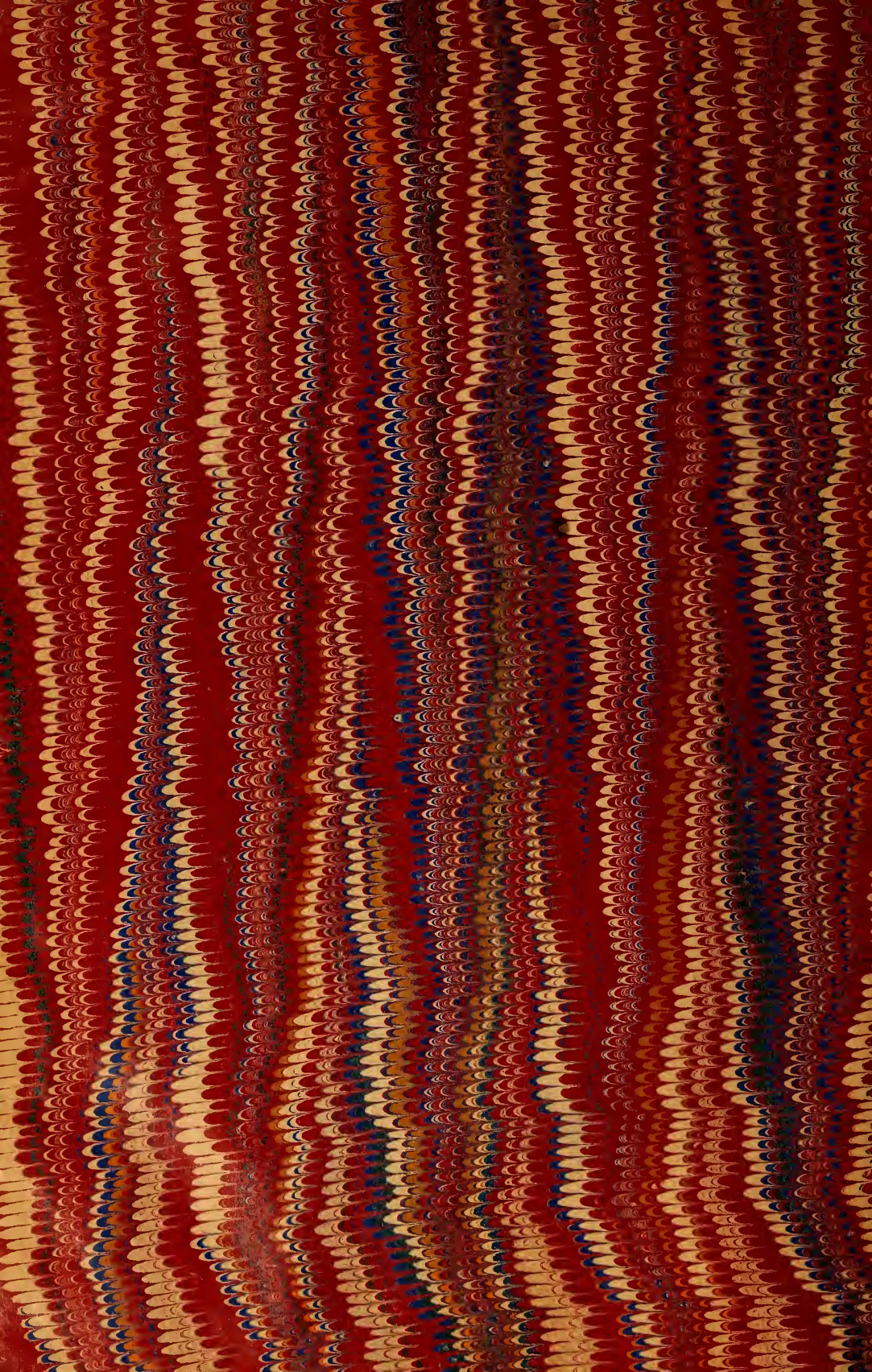
NOTE.—As the writer has been directed to continue this investigation, he will be duly grateful for any material evidence relating to the subject which it may be convenient for any person to place in his possession.

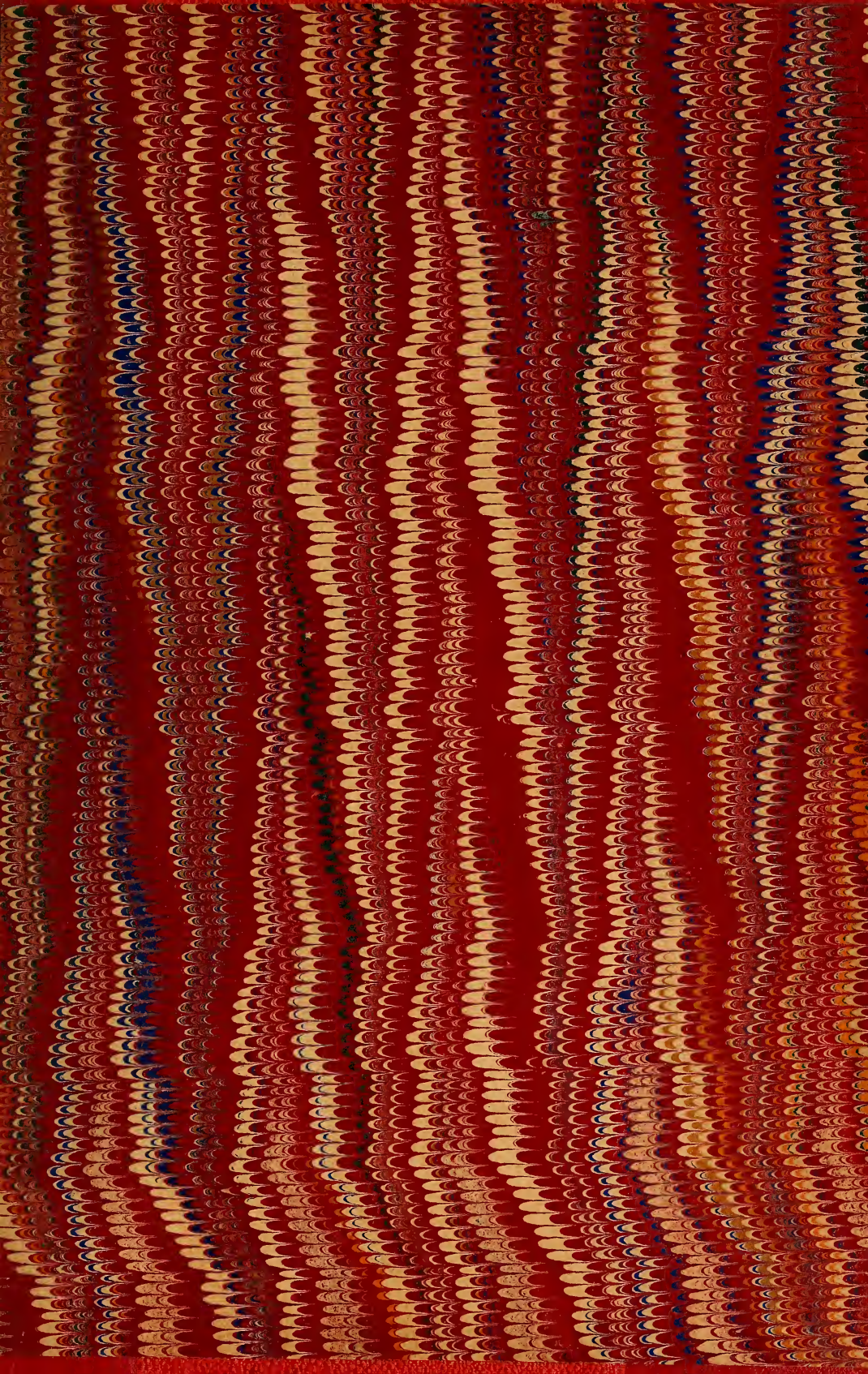
ERRATA: On page 134, the reference mark after “ill-ventilation” should be a star, and after the word “poison” a dagger. On page 137, line 21, read 35.6 instead of 356, and in line 22 read 101.9 instead of 1019. On page 142, line 22, read Schönleini instead of Schonleinu. On page 165, tenth line from bottom, read “flexure of forearm on arm.”





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